Vol. 15 DECEMBER, 1932 No. 12

Journal
of the
American Ceramic Society

Abstracts
Vol. 11, No. 12

Bulletin
Vol. 11, No. 12

A Monthly Journal Devoted to the Arts and Sciences
Related to the Silicate Industries

Publication Office: 20th & Northampton Sts., Easton, Pa.
Editorial and Advertising Office: 2535 N. High St., Columbus, Ohio.
Executive Office: 2535 N. High St., Columbus, Ohio.
Committee on Publications: J. T. Littleton, Chairman; Lewis Navias, L. J. Trostel, Milton F. Beecman, Ross C. Purdy.
Entered as second class matter at the post office at Easton, Pa., under the Act of March 3, 1879.
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CONTRIBUTIONS TO THE THEORY OF GLASS FORMATION AND THE GLASSY STATE*

By E. Berger[1]

ABSTRACT

An attempt has been made to assimilate the most important results of recent glass research into a theory of glass formation and the glassy state and to discuss it in relation to present knowledge of physics, chemistry, and colloidal chemistry.

The formation of glass from the liquid state, in contrast to crystallization, is a continuous path from the liquid, through the viscous (supercooled) to the brittle state. The transformation point (Tfp) represents the boundary temperature between viscous and brittle glass, at which boundary the property-temperature coefficients more or less suddenly change. Property values are influenced by thermal history which can not be explained by mechanical strains. Therefore, while a melt is cooled, an inner change of state, dynamic aggregation, is assumed which takes more and more time as the transformation point is approached and is completely checked at lower temperatures. The question of the thermodynamic stability of the glassy state thus becomes a problem. The difference between "unchecked" (lasting) and "checked" displacements of state is explained with respect to a series of properties.

From measurements of the viscosity and of the electric conductivity at temperatures from 1300 down to 300°C, it is shown that the liquid or viscous state follows a simple hyperbolic law, according to which these properties can only continue down to a lower limiting temperature (T_0) above the absolute zero point. The brittle state begins at the transformation point and follows a new law, knowledge of which is made more difficult by sooner or later "checking" the displacements of state. From the previous two different laws, it follows that brittle glass is something other than a supercooled liquid.

The transformation point can not be thermodynamically explained. Molecular kinetic considerations make it appear to be that temperature at which densest packing with a cessation of free molecular kinetic motion of the particles is reached. Changes in the brittle state are explained from an atom-kinetic point of view (shrinking of particle volumes) provided no changes in the state of aggregation occur. Dynamic aggregation takes place by the formation of primary and secondary particles. The structure of secondary particles is compared to a roll of coins and this picture is used to explain negative expansion under pressure, peculiarities in expansion curves, and the beginning of brittleness.

According to colloidal chemical considerations, the glassy or viscous states represent a solution of secondary particles as the disperse phase in a dispersing medium of primary particles and individual molecules, and the transformation point represents the boundary temperature between viscous and brittle glass paralleled by the gelatinizing temperature characteristic of the change from a sol to a gel. Support for the colloidal-chemical conception is obtained from observations on rapidly cooled glass melts and from reaction kinetics. Changes of property in the brittle and viscous states are proportional to the logarithm of the time, z, a law which is also found in elastic after-working, in isothermal dissociation of carbonates, and in some other instances. This law can be deduced from v. Smoluchowski's theory of coagulation. The disappearance of double refraction of chilled glasses due to annealing (cooling) can also be linked to the "log z" law.

I. Introduction

Glass technologists who are in daily contact with glass melting and working in industry are well aware that cold glass is a quite different substance from a solid crystal of the same chemical composition. They are constantly contending with stones and products of devitrification in the glass. Scientific establishment of this difference is of relatively recent date. Formerly, glass was thought to be a particular kind of stone, related

* Communication from Schott and Gen. Glass Works, Jena, Germany.

[1] Translation by my colleague, P. H. Prausnitz, and R. K. Day of the Corning Glass Works, whom I wish to thank at this time. Received July 23, 1932.

to the minerals with their relatively high melting points. However, in 1852 Hittorf[2] had shown that glass melts without absorption of heat, in fundamental contrast to the melting of a crystalline solid.

Certain conclusions about the glassy state had been arrived at due to the work of Tammann (I, II) and his collaborators in 1922. They started from the fact that when a liquid is cooled it is normally transformed into a crystalline solid. At the melting point of a pure substance, liquid and crystal are in equilibrium. The properties of the material therefore change from those of the liquid to those of the crystal at the melting point, in one jump. The mechanical properties are particularly changed: the liquid is transformed into solid, the energy content is suddenly lowered due to the releasing of the latent heat of fusion, and the volume is usually suddenly diminished. Similar sudden changes are observed in the optical properties, in the magnetic susceptibility, in the electric conductivity, and in other properties.

If the liquid is such that it can be supercooled (*i.e.*, should it be possible to maintain the liquid state below the melting point) either by rapid cooling or, in general, due to the substance's small tendency to crystallize, then the discontinuous changes characteristic of the transition from the liquid to the crystalline state do not occur. The liquid now passes into the supercooled state, changing its properties continuously in so doing.

According to van der Waals' equation of state, the intermolecular attraction (so-called internal pressure) must increase with decreasing temperature. This gives an explanation for the increase in viscosity with decreasing temperature. The supercooled liquid thus gradually passes through a syrupy state, then becomes highly viscous like pitch, and finally a hard brittle glass is formed.

The tendency of most industrial glasses to devitrify to a greater or lesser extent is counteracted by the increasing viscosity of the cooling glass. This is the usual explanation why glass which is many thousands of years old has not devitrified, in spite of the fact that it is thermodynamically unstable to the extent of the latent heat of fusion which it still contains. According to thermodynamics, only the state of lowest energy is stable. Scientifically speaking, glass has therefore been a more or less undefined, haphazard product, the constitution of which has been inaccessible to research because of its state of non-equilibrium. This generally accepted view has been emphatically pronounced as late as 1930 (Simon (I), Schmolke; compare also v. Raschevsky, and Simon (II)).

The beginnings of a new development in research on the glassy state date only ten years back. It is noteworthy that industrial laboratories are

[2] Literature references will be found arranged alphabetically in the Appendix. (p. 675). When several papers are written by the same author a Roman numeral is added after the name.

accountable for the largest efforts in this direction. The discovery of Quasebart (p. 18), for instance, published in a technical research on combustion technology in 1916, shows that in the heating of plate glass, an irregularity in the heating rate indicating absorption of heat occurs in a small temperature interval. Similar anomalies in the change from glass to the liquid state were published in 1920 by Tool (I) and Peters of the Bureau of Standards.

Much information on this subject has been recently published in many journals representing international collaboration of many countries. This makes it difficult to review critically the theory of glass formation and of the glassy state.[3] Although it is difficult to cover all this recent material, the author would like, in the following explanation, to try to assimilate the main points coherently, to add this to the present knowledge of physics and chemistry, and to point out the gaps and the problems which present themselves.

Since glass is a more or less complicated mixture of a number of raw materials, it will be easier first to study chemically simple substances, in particular some of the organic compounds.[4] It has been shown, however, that the formation of glass from the liquid state is a similar process, whether the material be a simple substance such as boric acid, selenium, glycerine, or one of several alcohols, or a mixture such as in industrial glasses. This situation presents in itself a problem whose solution would be of great value to our knowledge of the constitution of glass. On the other hand it is the hope of the glass industry that physicists and chemists will earnestly follow research on the glassy state, and that the results will be readily passed on to industry.

II. Property Changes during Glass Formation

Researches in glass of the last ten years have shown that the transformation from the liquid state through the highly viscous range to that of brittle glass does not take place so continuously as was formerly believed in the light of meager experiences. There are, however, no discontinuities such as that in the melting of a crystal. But in a small temperature range,

[3] Further references to the literature will be found under Eitel (I) and in abstracts of *Jour. Amer. Ceram. Soc.* and in *Jour. Soc. Glass Tech.*; also in *Glastech. Ber.* Glastechnische Tabellen by Eitel (II), is a splendid further source of literature references classified according to the properties considered here.

[4] It should be mentioned that from a glass technological angle it has been questioned whether these products should be given under the general classification of glass (Zschimmer, Vol. I, p. 127, who endeavors to limit the field of technical glasses). A note in *Glass Ind.*, p. 191 (1930) wishes to eliminate not only artificial resins (condensation products or irreversible glasses according to Berger (I), p. 404) and organic glasses, but also phosphate and borate glasses, thus restricting the name "glass" to silicate glasses. This limited definition will, however, soon cause difficulties in determining the boundary between borosilicate glasses and borax glasses. It seems more practical to retain the present generally accepted definition of glass as composed of the chief glass-forming substances.

or more exactly, at a temperature point, the temperature coefficients of the properties become discontinuous. This temperature has been designated the transformation point (abbr., *Tfp*, see Berger (I)). This point lies 100° or more (according to the substances) below the melting point (see Table I). Even in the change from liquid to crystal, besides the major melting discontinuity, there is a difference in the temperature coefficients on either side of the melting point. This is well known to apply at the transition point between two crystal forms of the same substance. The transformation point for glass differs from these other changes of state, particularly in that the discontinuity at the change of state does not involve a change in the numerical values of properties; it merely represents a point of discontinuity in the temperature coefficients.

To examine more closely the process of glass formation, it will be worth while to follow these property changes on several diagrams. Figure 1 shows the increase of volume with temperature of sodium thiosulphate as

TABLE I

ENERGY DIFFERENCE GLASS:CRYSTAL FOR VARIOUS SUBSTANCES

Substance	*Tfp* T_g° abs.	Melting point, T_s° abs.	Heat of fusion, *R* cal./g.	Energy difference $\Delta E_T = 0$ cal./g.
n-Propylalcohol	80	147	22.7	11.5
Ethylalcohol	84	159	25.8	13.9
Betol	128	366	18.0	6.7
Benzophenon	158	320	23.4	11.2
Glycerine	170	292	47.5	22.6
Selenium	303	493	16.4	2.9

measured by Samsoen (p. 96). In a chemically homogeneous liquid the volume diminishes almost linearly with decreasing temperature at a rate of δ per degree. In this case no changes occur as the freezing point, T_S, is passed. If crystallization took place without hindrance, the liquid would suddenly undergo a volume change, *EQ*, as it crystallized and would converge through QT_E to *Z*. The supercooled liquid does in fact change its volume along *EG*, where transformation takes place into the brittle state. From now on the glass contracts at a smaller rate, α per degree, which is usually nearly parallel to the volume curve for the crystal.

If, instead of a chemically homogeneous liquid, a mixture of substances *A* and *B* is considered, the picture of the changes into the crystalline state is different. If the substances do not form mixed crystals, the pure material *A* begins to separate at the point *E'*, and finally with decreasing temperature the substance *B* begins to crystallize at the eutectic point, T_E, and the mixture of crystals comes out in the same way as in the one-component system along the straight line, T_EZ. Freezing into the glassy state is not changed in dealing with mixtures. Chemically homogeneous materials as well as mixtures (industrial glasses) follow in a general way the

curve EGZ, irrespective of the size of the α and the δ values and the position of the Tfp-T_g.

Since the volume of a substance is determined mainly by the distance between the molecules (as determined by the kinetic energy of motion) in addition to the size of the molecules, the shape of the curve, which gives the relation between the energy or the heat content with the temperature, must be very similar to that for the change of volume. Figure 1 therefore shows in first approximation the temperature dependence of the energy content, E, except that instead of straight lines EG, GZ, and QZ, more or less curved lines have to be assumed because the energy of the intramolecular vibrations and of the rotation of the molecules must be added and α and δ no longer remain constant. The jump, EQ, then represents the heat of fusion, R, which is liberated during crystallization. Relations similar to those shown in Fig. 1 have been established for other properties such as density, refractive index, viscosity, electrical conductivity, dielectric constant, etc. In order not to lose sight of the main point, for the present the author will not go further into the details of such diagrams (see Berger (II)).

It is noteworthy that in the case of noncrystalline freezing, all property curves break at the transformation point, T_g, the temperature coefficients undergoing sudden changes at this point. Figure 2 shows this clearly by the dependence of the expansion coefficient $\frac{dV}{dT}$ on temperature, as shown by the measurements on thiosulphate according to Fig. 1; a constant small expansion of the glass is followed by an expansion 2 to 10 times larger in the viscous state. Figure 2 also shows the temperature coefficient of the energy content, $\frac{dE}{dT}$ (usually designated by C_p), for glycerine as measured by Gibson.

At the melting point the energy content of fluid glass is larger than that of the corresponding crystal by the heat of fusion, R, but it diminishes at a greater rate per degree during cooling while viscous than in the case of the crystal. A close approximation of the energy content (and of the volume) of glass and crystal can be obtained in this way, their energy difference being much smaller in the brittle state than at the melting point (see Fig. 1). If the tendency of brittle glass to crystallize (secondary or catalytic influences of absorbed water are hereby not considered, see Tammann (III), Tian) has not yet been definitely proved, then, in addition to the high viscosity, this convergence of the energy contents may be the explanation.

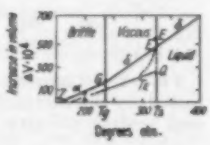

FIG. 1.—Dependence of the volume on the temperature during glass formation and crystallization.

If it is assumed that below the Tfp the specific heat of glass and crystal is

the same, as has been indicated by experiments (see Fig. 2), then the energy difference (ΔE) between glass and crystal may be calculated.

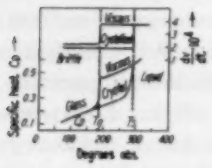

FIG. 2.—Temperature coefficient of the volume (expansion) and of the heat content (specific heat C_p).

Table I gives values (largely by Tammann (IV)) for various materials arranged in the order of increased *Tfp* temperatures, the melting point, the heat of fusion, and the energy difference (ΔE), calculated at the absolute zero of temperature. It is easily seen that there is no relation between the *Tfp* and the fusion temperature (see the attempts of Tammann (IV)); similarly there is no obvious relation between these temperatures of the heat of fusion or the energy difference, ΔE. Yet if one plots heat of fusion, R, against energy difference, ΔE, as in Fig. 3 (Berger (II)), there seems to be a relation between these quantities. According to this it would be expected that the energy difference between glass and crystal would become negative for materials whose heat of fusion is less than about 12 calories per gram. In this case, glass would be the thermodynamically stable form. The crystalline state could only be designated the more stable in a certain range of temperature, whereas at lower temperatures it would tend to transform into a glass.

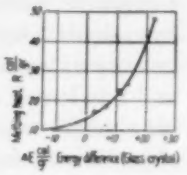

FIG. 3.—Relation between the energy difference (ΔE) and the heat of fusion, R.

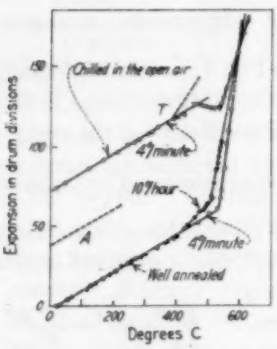

FIG. 4.—Expansion as affected by the thermal history and heating velocity.

III. Dependence of Properties on Thermal History

In addition to knowing that the change from the liquid to the glassy state is discontinuous even though steady, and that brittle glass is separated from viscous glass by a more or less sharply defined discontinuity at the *Tfp* where a change in the temperature coefficients of its properties takes place, recent research has shown that the properties of a glass are not entirely defined by designating the variables: pressure, volume, and temperature. The properties (or the state of the glass) are still further dependent on the temperature history of the glass (Berger (II)).

Figure 4 gives the expansion measurements of an optical glass, BK 7, after various thermal histories.[5] The samples were taken from an astro-

[5] These experiments were carried out by Dr. Klemm and Miss Tiedemann, for which the author hereby wishes to thank them.

nomical telescope disk which had been annealed with extreme care and which was practically free from strain.[6] A 1-centimeter thick piece of glass cut from this disk was set up in the measuring apparatus[7] and was heated at a rate of 4° per minute. As shown in Fig. 4 the length expressed in drum divisions[8] of the micrometer eye-piece, increased linearly with the temperature to over 500° and then suddenly increased much more rapidly. The break in the curve designates the *Tfp* (see Fig. 1), the change from brittle to viscous glass. A second sample was heated more slowly at a rate of 10° per hour. Up to 400° the points are practically on the same straight line, but then an increased expansion occurs. The higher expansion of the fluid state has started at a lower *Tfp*.[9]

A third test was carried out by holding a sample for one hour at 560° after which it was quenched in air. The density of this sample proved to be 0.0214 smaller than the untreated sample, showing an increase in volume. Accordingly, the starting point of the curve obtained from the 4° per minute heating rate lies higher than that of the previous ones. It is seen that up to 400° a straight line parallel to the former is followed but that below 500° the glass begins to shrink and does not change back into the large positive expansion of the viscous liquid state until above 500°.[10]

Thus different temperature cycles besides simple temperature changes cause additional changes in the glass. These changes have been attributed in the past to mechanical strain but such an explanation, for various reasons, can not be accepted. In the first place, the surface layers of quenched glass in general are under compression. By means of a Pulfrich refractometer the refractive index of these surface layers can be measured. Since they are under compression an increased index of refraction is to be expected. Actually, a smaller index is observed in a quenched, strained glass than in well-annealed glass.

A second explanation of the low density of quenched glass may be that

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[6] The annealing period extended over several months. The maximum double refraction at the edge of the disk was less than 5 mμ/cm. optical path difference so that the difference between the refractive index of the ordinary and extraordinary rays would not exceed 0.0000005.

[7] The methods of measurement are described in detail by Berger (III).

[8] One drum division is equal to 0.0000714 cm.

[9] These experiments prove the invalidity of Koerner's assertions (see criticism by Berger (VII)).

[10] For the sake of clearness, the curve representing the heat-treated glass is drawn higher up than the calculated change in density. It ought to start at *A* and follow the course indicated by a dotted line. The slighter inclination in the viscous state is not entirely due to thermal history, but particularly due to flow owing to the pressure in the apparatus. This is particularly noticeable in the case of chilled glass because of its lower viscosity as shown in Fig. 6. Further measurements, which are to be published shortly, indicate that when working rapidly under the smallest possible pressure, chilled glass shows a *Tfp* at *T* and following the adjoining dotted path. This path can not be easily determined because of the changes taking place in the glass so that a course will be followed similar in type to the upper complete curve.

the glass has not had time to shrink. But the density of a mechanical strained glass does not change much through pulverizing. Salmang (pp. 473 and 481) shows that the density of a quenched so-called Prince Rupert drop increases from 2.4439 to 2.4446 when the strain is released (exploded and ground to a fine powder). Careful heat treatment of this powder increased its density to 2.4620. The change in density caused by releasing strain is therefore only 3.8% of the total change in density caused by heat treatment.

The experiments of Fig. 4 further show how unsatisfactory it is to try to explain these phenomena by strains set up in the glass. Since the quenched glass has too small a density (*i.e.*, its volume is too great), the contraction in the upper curve could be explained by the assumption that the viscosity below the *Tfp* is too small to neutralize the strain and allow contraction there. Both lower curves apply to well-annealed glass with practically negligible double refraction. That the strains introduced by heating (*i.e.*, through delay in reaching temperature equilibrium) in the 4° per minute heating rates have no effect on the volume is shown by the fact that the straight line representing the 4° per minute rate practically coincides with that representing the 10° per hour rate. If, therefore, analogous to the shrinking of the quenched glass, the increase in volume before reaching the *Tfp* in the case of 10° per hour heating rate is to be explained by a release of strain, then one must assume that glass which is cooled very slowly will end up in compression. It can not be understood then why this compression did not disappear by the aforementioned very slow cooling of the sample.

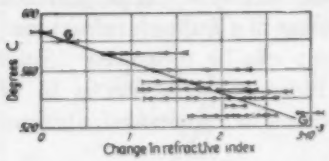

FIG. 5.—Displacement of refractive index up to the equilibrium value.

Since changes in the properties of glass with thermal history can not be explained by strain phenomena, one is forced to assume that during cooling, inner chemical changes take place in the liquid and in the glass and that these changes take place more or less slowly and can therefore be checked (Berger (I, IV)). If glass is kept at any temperature for a long enough time it should reach equilibrium. Many refractive index experiments (Stojaroff, Lebedeff, Berger (IV)) have definitely shown that this equilibrium point can in fact be reached from both directions.

Figure 5 shows some of Stojaroff's results. From the composition of the experimental glass it can be concluded that all the measurements were made above the *Tfp*. Stojaroff put a glass prism into an electric furnace and measured the refractive index during heating. By rapidly increasing the temperature and thereafter holding it constant, he obtained a measurement to the right of the oblique straight line, *GG*. This value gradually

shifted to the left with time, until the point on the line *GG* was reached. Through rapid cooling, then holding constant, he obtained a value to the left of the line *GG* which in time shifted to the right up to the new constant temperature value on *GG*. It is obvious that, from both sides, the ultimate equilibrium end points all lie on a straight line, *GG*, which represents the dependence of refractive index on temperature under conditions of equilibrium. The author wishes to name such a change of state "a lasting change of equilibrium." The other points can be undoubtedly explained by the fact that the inner changes were checked or had not yet come to equilibrium. It is necessary, therefore, to differentiate between "checked" and "lasting" displacements of state, according to whether the exterior variables, pressure and temperature alone, or the interior variables of state also, *i.e.*, the equilibrium value or the transformation factor for the inner chemical changes, have been thoroughly defined (compare Ulich, especially pp. 54 and 71; a short description is also given in Berger (II) p. 351).

TABLE II

TIMES FOR COMPLETE ATTAINMENT OF EQUILIBRIUM

50°C above the *Tfp* about 20 min.
At the *Tfp* (static) 1000 min.
50°C below the *Tfp* 6000 min. = 100 hours
100°C below the *Tfp* 60,000 min. = 1000 hours = 40 days
200°C below the *Tfp* (extrapolated) = 92,000 hours = 3800 days = 10 years
300°C below the *Tfp* (extrapolated) = 70,000 days = 200 years

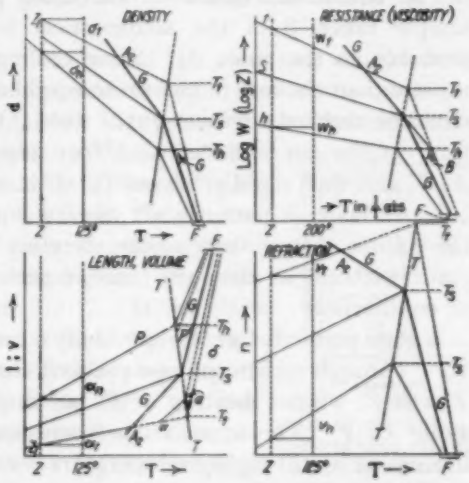

FIG. 6.—Dependence of different properties on the thermal history.

The time necessary to reach complete equilibrium becomes much longer as the temperature is lowered. Table II gives a few values for general orientation found while studying the refractive index of lead glass (Berger (II, IV)). The numerical values may be lowered for other glasses; for instance, divided by three for a borate glass (Berger (V)). Yet it is obviously difficult to determine experimentally the lasting displacements of equilibrium at low temperatures. Refractive index measurements, however, have been quite successful and have shown that these lasting

changes of state fall on curves or straight lines with a bend at the *Tfp* (a static *Tfp* because it refers to a temperature held constant for any time (at will) (Berger (IV)).[11]

Thus recent researches on glass have established that the glassy state, irrespective of whether stable or unstable with respect to the crystalline state, can represent a fully defined equilibrium which needs, however, for its complete description the physical variables, pressure and temperature, in addition to the inner chemical variables of state. From this point of view, the many unusual discoveries due to differences in thermal history can be explained clearly and without reservations.

Figure 6 shows the most important property changes schematically (for fuller explanations see Berger (IV)). The graph dealing with the length and volume corresponds approximately to the results of Fig. 4, *viz.*, for an equilibrium reached at a low temperature, one reached at the static *Tfp*, and one reached at a high temperature. In agreement with Table II, equilibrium is rapidly established at high temperature and all curves converge in the point, *F*. The volumes or lengths representing lasting equilibrium changes are shown on the straight lines, *GG*.

The equilibrium point of the most particularly well-annealed glass sample taken from the astronomical telescope disk shifted along *GG* probably to the point A_2. Since cooling at this point took place more rapidly than the rate of change to equilibrium, the straight line A_2Z represents the checked displacement of state. If the sample at this low temperature equilibrium is heated at 4° per minute, the expansion follows along A_2aT_t and then rapidly toward *F*. If it is heated more slowly at a rate of 10° per hour, a partial shift toward equilibrium takes place along *aa;* the volume change along *aa* can therefore be explained by inner changes of state without, at the same time, representing the lasting displacement of equilibrium.

A glass preheated at 500° probably corresponds to the equilibrium value, T_s. Through rapid cooling a checked change of state takes place between T_s and *Z*, whence heating at 4° per minute brings the expansion curve along ZT_sF. The upper curve corresponds to a sample from an equilibrium at a still higher temperature. Heating at 4° per minute follows the straight line *ZP* and at the point, *P*, an inner chemical change takes place together with a smaller temperature coefficient along *PP'* followed by the rise of the liquid toward *F*.[10]

The lines in Fig. 6 representing density can be fully explained as reciprocals of volume. Optical refractive index changes are similar to mechanical changes of density. It is interesting, however, that with most glasses,

[11] This means that the *Tfp* separating viscous from brittle glass in general does not coincide with the freezing-in-point (Einfriertemperatur, see Simon (II)) (where inner chemical changes practically stop for common (or usual) rates of cooling (see Berger (II), p. 356)).

the checked displacement of state shows an increase in refractive index with increasing temperature, while lasting displacements show a decrease with increasing temperature. Finally, electrical resistance and viscosity give similar pictures when logarithmically plotted against $\frac{1}{T}$. It is noteworthy from this that while cooling at a certain temperature even the viscosity of a quenched glass increases[12] (similar to the displacement of refractive index in Fig. 5). Previous viscosity measurements which were apparently made during rapid cooling show a sharp break at the *Tfp* and only a slight increase in the brittle state (Gehlhoff (I, II), Tammann (V)). More recent measurements by Lillie, during which the temperature was more slowly lowered, show only slight breaks. It will be later explained why a *Tfp* clearly exists in spite of this.

Since volume and energy changes correspond to each other, each contraction of a quenched glass along *PP'* in Fig. 6 represents emission of heat; each dilatation of a well-annealed glass along *aa* represents absorption of heat. These relations have been carefully studied by Tool (II) who heated powdered glass next to a neutral body in an electric furnace, at the same time carefully noting the temperature-difference between the two substances.

If the furnace temperature is uniform and the glass and neutral body have the same specific heat, such experiments should show no temperature-difference between the two substances. If, however, the glass suddenly undergoes a large increase in specific heat as at the *Tfp* (see Fig. 2) the glass powder will absorb more heat per degree of temperature rise than the neutral body, the temperature of the glass thereby slightly lagging. The relation between this lag and the temperature is shown as curve *C* of Fig. 7. If the glass powder has been quenched from a high temperature equilibrium, an emission of heat will take place during heating before reaching the *Tfp* along *PP'*. In this range the glass powder uses up less heat than the neutral body and therefore shows a higher temperature until a sudden increase in the specific heat again lowers the temperature of the glass with respect to the neutral body. These phenomena are shown by curve *A* in Fig. 7. If the glass powder had been previously well annealed, being in low temperature equilibrium, a heat absorption along *aa* (Fig. 6) is added to the sudden increase in specific heat near the *Tfp*. The temperature of the glass powder therefore suddenly drops far below that of the neutral body until the

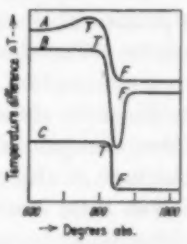

FIG. 7.—Heat effects and specific heat during transition from brittle into viscous glass.

[12] Similar phenomena are met with in a gelatinous solution (see Freundlich, pp. 628, 632).

heat-absorbing inner changes in the glass are largely completed and normal conditions are restored. Curve *B* of Fig. 7, representing this case, therefore shows a steep minimum and is then similar to curve *C* above *F*. Depending on the thermal history, various combinations of the curves *A* and *B* can be obtained (see Tool (II)).

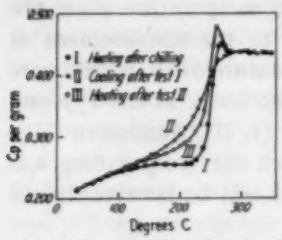

FIG. 8.—Specific heat of glassy and of liquid boric oxide (B_2O_3).

These experiments are nothing more than measurements of the specific heat, C_p, except that a minimum on curve *B* represents a maximum of energy increase. Actually, specific-heat curves of glasses resemble quite closely curves *A* and *B* of Fig. 7 as shown in Fig. 8, giving the more recent measurements on molten boric acid (B_2O_3 glass) by Thomas. Curve I represents a quenched high-temperature equilibrium, and the general form of curve *A* (Fig. 7) is recognized. Curve 2 represents slow cooling of the same sample and curve 3, a subsequent heating of the same annealed glass. The maximum in this curve clearly corresponds to the minimum in curve *B*. The rates of heating and cooling in these experiments could not exceed about 0.3° per minute.

In spite of the extreme care with which these experiments were obviously carried out, curve 3 in the writer's opinion does not represent the true temperature dependence of specific heat for lasting displacements of equilibrium, since retarded internal chemical changes obscure the measurements. The slow rate at which equilibrium is obtained (Table II) makes measurements of the specific heat for lasting equilibria particularly difficult or even impossible because the slow changes in a calorimeter overshadow the slow changes in the glass. It is experimentally easier to follow these lasting changes of state through volume measurements, and from these investigations results such as the following may be expected (Berger (II)).

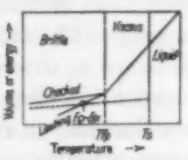

FIG. 9.—Properties of glass for checked and lasting equilibrium displacements in relation to the crystalline state.

Figure 9 should remind us of Fig. 1. It may be presumed that the investigation on thiosulphate took place so rapidly that in the brittle state an equilibrium at the *Tfp* was at best established and then checked. While studying lasting equilibrium displacements, the volume curve should follow that labeled "lasting" and it is realized then that at any point the volume (and this applies also to the energy content) of glass and crystal will be equal. The statement that the crystalline represents the thermodynamically stable state only up to an end temperature as a lower limit has, in the light of these latter considerations,

a much larger general significance than first appeared from Fig. 3. Boric acid glass which has never yet been crystallized would be a material having a very small or non-existent range in which the crystalline state can exist. This might apply to materials such as potassium metasilicate (Tammann (II) pp. 231, 234) and many organic substances.

IV. The Lower Limit of the Liquid State and the Transformation Point

The temperature at which glass and crystal have the same energy content (Fig. 9) must not necessarily be the same as the *Tfp* temperature, nor must it coincide with the static *Tfp* for lasting equilibrium displacement. Therefore, the *Tfp* has probably no thermodynamic significance. Its theoretical explanation must be considered from other angles which will now be discussed.

Van der Waals' equation of state for gases and liquids would lead one to

$$\left(p + \frac{a}{v^2}\right)(v - b) = RT$$

believe that the liquid state continues down to absolute zero. At this point the kinetic energy of motion of the molecules vanishes and, as $v - b = 0$, the volume will be a minimum, namely, the volume of the molecules closely packed. The value, $\frac{a}{v^2}$, *i.e.*, the intermolecular attraction, becomes a maximum. It is believed that at absolute zero the particles actually touch each other and that the attractive forces are so large that a rigid body exists.

It is well known that van der Waals' equation is not strictly followed by any material principally because it supposes that all of the molecules of a chemically homogeneous material are similar spheres and that chemical changes do not take place during cooling. For these reasons large deviations from the formula are found in so-called associated materials, in which it is presumed that the individual molecules actually present in a gas, as they approach the glassy state upon cooling from the liquid state, form clusters or groups of two or more molecules. Because of the dependence of the properties of a glass on its thermal history, the assumption has heretofore been accepted that chemical changes take place with falling temperature. Probably all of the glass-forming materials actually belong to this associating group.

An equation of state for liquids tending to associate does not yet exist, but there have been some attempts in this direction. It has been found (Meyer-Bjerrum) that certain substances that do not follow van der Waals' equation will follow a so-called reduced equation of state referred

to the critical values, in which the temperature and volume are measured from a higher temperature, T_0, rather than from the absolute zero point. This would mean that these materials reach the end point of the liquid state at a higher temperature, T_0, rather than at the ideal van der Waals' absolute zero. This discovery (1910) has not been recognized to be of theoretical significance (Kuenen, p. 147). No further notice was taken of other recent references that the temperature coefficient of the density of liquids is such that below a certain temperature the liquid state no longer seems to exist (Salzwedel and discussions by Berger (II)).

The laws observed by viscosity and electrical resistance as a function of temperature lead to the same conclusion and recent measurements of these properties are so definite that the assumption of an end temperature, T_0, as a lower limit of the liquid state increases in plausibility. The laws relating viscosity of liquids to temperature have only recently been made more clear (Drucker (I), Sheppard). Various assumptions have led to the same formula according to which $\eta = A \cdot e^{B/T}$ and the measured values on many substances fit this formula exceptionally well. A likely theoretical explanation may be arrived at in the following manner (compare the comprehensive discussion by Sheppard).

It is now known that chemical reactions can take place also in the solid state, for instance, in a mixture of crystals. This is explained by assuming an exchange of places between molecules or molecular groups (see Jander (I), Hedvall). Viscous liquids are mechanically similar to solid materials and it seems therefore likely that the slipping of liquid layers over one another could be explained by an interchange of position of molecules or particles (Terzaghi). Of all the particles of N_0, a certain portion, N, will have a sufficiently higher temperature or energy content to migrate. $\frac{1}{\eta}$ must therefore be proportional to N. According to Maxwell's distribution law the number, N, which will change their position is related to the absolute temperature according to the formula $N = N_0 \cdot e^{-\varepsilon/T}$. It is obvious that this leads directly to the equation $\eta = A \cdot e^{B/T}$.

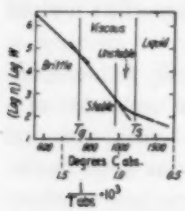

FIG. 10.—Logarithms of viscosity and electric resistance plotted against reciprocal of the absolute temperature.

It has been shown that this simple formula is not accurately satisfied by associating materials (Sheppard, p. 366). Large deviations occur, particularly at low temperatures. Measurements on glass (see Fig. 10) have shown that in the viscous and fluid state a linear relation between log η and $\frac{1}{T}$ is only approximately observed in small temperature intervals above the *Tfp*. The same is true of the

electrical resistance. Smekal explained this deviation from a straight line by differentiating between a stable and an unstable viscous state (compare criticisms by Berger (IV), pp. 340, 365).

Some time ago Tammann ((II), p. 245) pointed out that the curve representing viscosity as a function of temperature has the same shape for all sorts of organic substances, and that the viscosity curves of almost all the investigated materials can be brought into coincidence if they are displaced along the temperature axis. This means that log η is proportional to $\frac{1}{T - T_0}$ instead of $\frac{1}{T}$. Tammann (V) studied the organic glasses and Fulcher the industrial glasses and both found that the relation $\log \eta = A + \frac{B}{T - T_0}$ quite accurately represented the measured values. Figure 11 shows how closely more recent measurements fit this equation.

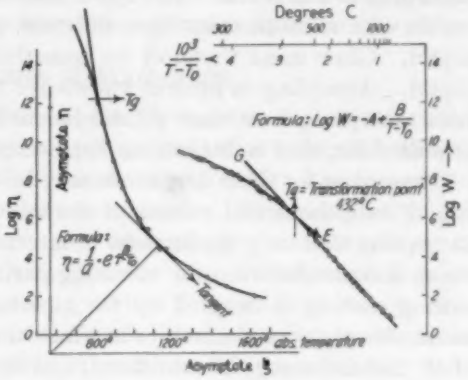

FIG. 11.—Logarithm of viscosity as a function of temperature; logarithm of the electric resistance against $1/T - T_0$.

On the right hand side (Fig. 11) the logarithm of the measured electrical resistance[13] is plotted against $\frac{10^3}{T - T_0}$, in which T_0 has been computed to be 334°A (61°C) by averaging the experimental errors. It is readily seen that the experimental points fit a straight line accurately between 432°C and 1200°C. This means that at T_0, the resistance (and the same holds true for viscosity) should become infinitely large. This temperature therefore represents a condition which can be compared to the absolute zero in van der Waals' equation. If the resistance or, as in Fig. 11, the viscosity (according to the measurements (III) of Lillie (p. 511)), is logarithmically plotted against the absolute temperature, an equilateral hyperbola is obtained whose asymptote goes through the point T_0 (in this case 567°A or 294°C). It follows from this, as has been previously pointed out, that glass-forming (associating) liquids have properties theoretically such that the liquid phase stops at the temperature T_0 above the absolute zero point.

[13] These measurements were made on a bulb lead glass at the Osram Laboratories in Berlin and have been kindly placed at my disposal with permission of preliminary publication by Dr. Thomas, whom I wish to thank heartily. More accurate numerical data and specifications on their determination will most likely appear in *Glastech. Ber.* Below the *Tfp* difficulties arose in establishing the final equilibrium.

As is also shown in Fig. 11, the experimental hyperbola does not actually go through the end point T_0. At the *Tfp*, T_g, the curve, is deviated according to a new law. The *Tfp* is therefore that temperature at which in reality the substance assumes different properties than those of a true liquid. Glass must therefore be something different from a supercooled liquid. According to present knowledge these deviations from the hyperbola take place even when establishment of complete internal equilibrium is waited for, that is, for lasting displacements of state.

The reason for these deviations may be that in the hyperbolic law of the liquid state the actual volume of the molecules is not taken into account. It appears that only the increase in internal pressure or the decrease in the mean distance between the vibrating particles, which move closer together during cooling, is covered by the equation. If the analogous picture of molecules of the gaseous state in which they are free to move about due to their thermal energy is considered, and this picture is applied to the liquid state, then a molecular kinetic picture of the liquid state, according to van der Waals, is only possible so long as a free thermal motion of the particles exists. According to this molecular kinetic conception, the liquid state must end when the particles get so close together that they touch each other and the forces of cohesion of the solid state come into existence. The free thermal motion of the particles then becomes zero. This close-packing state being reached at the *Tfp*, properties are no more affected by kinetic processes, but only by atomic kinetic molecular ones. Changes in the volume, energy, etc., not considering inner chemical changes, take place during further cooling, in that the atomic motion and the space taken up by the molecules, *i.e.*, their volume, diminish. At the freezing point free molecular kinetic energy of the liquid is released and the crystal particles assume definite positions; similarly the last molecular kinetic motions of the supercooled liquid cease at the *Tfp*, and below the *Tfp* the liquid state is replaced by a rigid brittle state (glass) named the fourth state of matter by Parks, or the third isotropic state by Tammann (II) p. 2. According to these molecular kinetic considerations, it appears that the *Tfp* is the boundary line between the liquid state and glass (compare Berger (II)).

A confirmation of this conception is to be obtained in the experimental fact that apparently at the *Tfp* of all glasses the viscosity η has a value of 10^{13} c.g.s. units (poises), regardless of whether chemically simple substances or mixtures such as industrial glasses are investigated. According to the viscosity formula of Einstein and of Hatschek for concentrated colloid solutions (see Freundlich p. 311), η is proportional to $\frac{\text{volume of particles}}{\text{total volume}}$. Investigations on the most closely packed powders show that within certain limits this proportion is a constant, independent of the size and nature of the

particles (Westman p. 769; see also Manegold). Since densest packing was assumed at the *Tfp*, we arrive at a theory that all liquid substances and mixtures, at least with respect to viscosity, reach a similar state at the *Tfp*, this temperature corresponding by analogy to a critical temperature for them.

V. Dynamics of Aggregation

In order to explain the heat effects at the *Tfp* and the dependence of the properties on the thermal history, we have assumed that molecular changes take place during the cooling of a glass-forming liquid. The hyperbolic law and the existence of a boundary temperature, T_0, analogous to the absolute zero, lead to the same conclusion when the proper assumptions are made, *i.e.*, when several particles aggregate into a cluster, energy is liberated. It is easily seen that, owing to this diminution of energy, at a higher temperature, T_0, such a state is reached, which corresponds to the absolute zero point or to the ceasing of molecular kinetic motions. If it were possible to carry out a mental experiment in which, at the constant temperature, T_0, the energy liberated by the aggregation of the particles were forced back into the system, then the particles of the molecular group would again be separated and obtain a certain kinetic energy or free thermal motion. We would again have a liquid at the temperature T_0 in which the molecular kinetic heat content would not vanish until a lower temperature or the absolute zero was reached.

The theory of associating liquids can only be constructed on the assumption that, with falling temperature, progressive or dynamic aggregation of the particles takes place. (In this case, the words "aggregate" or "aggregation" shall mean quite generally the combination of pairs or larger groups of individual molecules.) This applies regardless of whether the binding forces are electrical, van der Waals, chemical, or other forces. Dynamics of aggregation will therefore be taken as a foundation for a theory of liquids. This theory will be only rapidly sketched here; a more thorough treatment of the subject must be reserved until later.

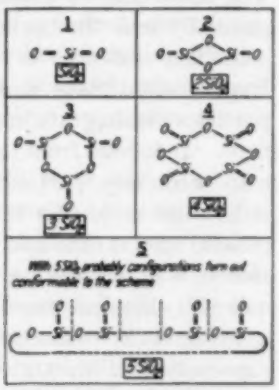

FIG. 12.—Structural formulas of SiO_2 with increasing polymerization.

What aggregates exist and how they are formed is at present known in only a few cases. It seems established, however, that the formation of primary particles and of secondary particles, or more generally those with stronger or looser bonds, can be differentiated. It has been found, for instance, that organic substances like styrol can be polymerized by chemical bonding (principal valences) of individual molecules into long

chains (or double chains). In this way one-dimensional primary particles or macro-molecules, consisting of 100 or 1000 molecules joined together, can exist. It has been shown that other materials polymerize to form two-dimensional plate-like macro-molecules as primary particles, and recent investigations show the existence of primary particles in three dimensions.

The work of Signer on the polymerization of silicic acid esters is of interest in this connection. If these observations are applied to silicon dioxide and its polymerization (see Dilthey), various polymerization steps are obtained such as those shown in Fig. 12. We get, generally speaking, chain formations of SiO_2 components in closed rings as represented in part 5 (Fig. 12). Signer adds that silica aggregations of five components will have a three-dimensional configuration. The work of Bragg shows as a similar example various space lattice configurations depending on the ratio between Si and O.

According to the kinetic theory of thermal energy, the most stable state of a substance is that having the most regular arrangement of its molecules. A structure of primary particles as described leads to a more highly ordered state when compared to the unassociated liquid state and this may explain why glass can represent a thermodynamically stable state, in accordance with our previous arguments (compare Simon (II)).

Even though we can not generally say that gigantic primary particles are found in all glass-forming liquids, it has been clearly shown that these macro-molecules further associate into larger aggregates (Staudinger (I)). The same may be assumed for smaller primary particles. It is probably generally true that primary particles can associate through the action of secondary valences or dipole forces to form larger secondary particles. Experimental data make it necessary to assume that these secondary particles disintegrate into individual primary particles with rising temperature. It follows from this, that the forces which bind the primary particles into secondary particles are much weaker than those which bind the individual molecules into primary particles. At the same time a more general idea is obtained of what goes on in the course of dynamic aggregation in a liquid and its transformation into the glassy state (compare the colloidal chemical conceptions of Malfitano).

I should like to discuss the structure of a secondary particle which may be especially well illustrated by a roll of coins. If we represent the primary particles by small plates such as coins held together by large internal forces, the secondary particles may be represented by an aggregation of these primary plates into a stack or roll of coins. This picture of a secondary particle serves to explain why such particles show little resistance to bending.

A similar picture was used by Tammann (VI) to explain the behavior of

glasses under high pressure from all sides. He melted boric acid or organic glass in a cylinder under a pressure of about 2000 kilograms per square centimeter. He observed the changes in volume with falling temperature by observing pressure changes with a manometer. The results (Fig. 13) show that the volume diminishes regularly down to the *Tfp*, then rises for a bit, and at lower temperatures continues to diminish. To explain these remarkable phenomena, Tammann believes that the secondary particles, having a structure like a roll of coins, are bent under pressure so that they occupy a smaller volume than a similar glass melt heated to the same temperature (above 50°) at a pressure of one kilogram per square centimeter. The two small square pictures of Fig. 13 illustrate this theory. Tammann computes from cross-sections that, in equal volumes, the one contains twenty-six bent particles and the other twenty-one unbent particles of the same length.

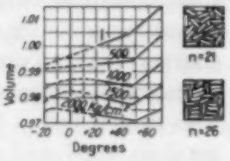

FIG. 13.—Volume structure and volume isobars of glass under pressure from all sides.

The initial decrease in volume down to the *Tfp* during the cooling experiments under 2000 kilograms per square centimeter represents the decrease in the kinetic energy of the bent secondary particles. If it is assumed that with further decrease in temperature the ability of the rolls of coins to bend diminishes (*i.e.*, they become stiffer), then the volume decrease caused by simple cooling will be outweighed by an increase in volume caused by stretching. The expansion coefficient therefore becomes negative in a certain temperature region, until finally all the particles have reached a state of greatest stretching, and further shrinking of the particle volumes takes place according to pure atom-kinetics.

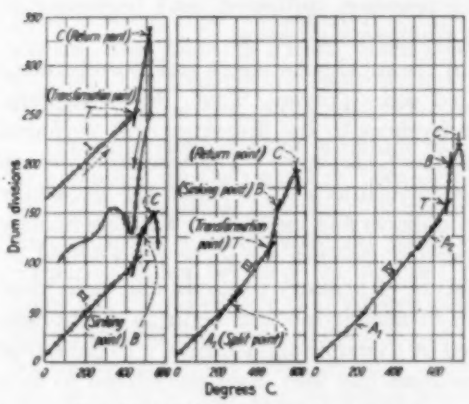

FIG. 14.—Typical expansion curves.

Should these ideas be correct, certain peculiarities in the expansion curves under ordinary pressures can similarly be explained. It has been shown that some glasses, when heated at a rate of 4° per minute, do not show a linear expansion up to the *Tfp*, but rather one represented by two straight lines with a break. Figure 14 shows some typical expansion curves (Berger (III)). Up to this time we have dealt only with unbroken straight-line relations like curve II. It appears from

curve III that these straight lines can be broken up into two parts with a break at A_1, the so-called "splitpoint." Curve IV shows a further break at A_2 which can probably be explained by inner displacements of state according to the line *aa* of Fig. 6. But the splitpoint, A_1, must still be explained. Its existence has been sufficiently verified by experiments (Berger (III), Turner, Cohn) and it has also been found in refractive index measurements (Berger (IV), p. 342; on page 362 the work of Turner, who established a further point of discontinuity at lower temperatures between 100° and 140°, is critically discussed). If the stiffness of the rolls of coins diminishes with increasing temperature, this can easily be construed as a loosening of the weak bonds of the secondary particles. The amplitude of thermal oscillations of the individual coins increases causing a larger expansion and serves to explain the splitting up of the expansion curve into two straight lines with a break at the splitpoint, A_1.

Still another phenomenon may be explained according to this conception. Tammann (VII) found that the point of discontinuity in the temperature property coefficients (*Tfp*) coincides for many substances with the beginning of brittleness; that is, the temperature at which the scratching or jarring will start the formation of cracks. Tammann (VIII) found, however, that brittleness in polystyrol and polyindene glass would not begin until well below the *Tfp* and he therefore calls these abnormal glasses. The work of Elsner v. Gronow on several industrial glasses shows the same abnormal phenomena. This can be explained by a decrease in stiffness of the secondary particles at a definite temperature (beginning of brittleness). Negative expansion under pressure, splitpoint, and beginning of brittleness can thus be classed as similar phenomena.

The similarity between colloidal chemical substances and glass-forming substances has often been pointed out (Travers, Tool, Bary, McBain, Parks, Berger (I), and others; references to the literature will be found under Eitel (I) pp. 140, 150 as well as Liesegang). The viscous state can be compared with a colloidal solution such as a sol in which the secondary particles are the disperse phase in a dispersing medium. With chemically homogeneous substances the dispersing medium would be represented by the primary particles or by a mixture of primary particles and individual molecules or smaller polymers, this dispersing medium being in equilibrium with the secondary particles formed by dynamic aggregation. In industrial silicate glasses, the dispersing medium has also been considered to be a sodium silicate liquid and the disperse phase to consist of electrically charged colloidal particles, so-called micels (Lange). This conception is not one of general significance (for instance, in SiO_2, B_2O_3, or selenium glasses) so that we had better neglect consideration of this possibility. The same applies to a conception recently communicated by Weyl that the behavior

of viscous and brittle glass is to be explained by a solvation of ions, *i.e.*, formation of envelopes by solvent particles around ions.

From the point of view of colloidal chemistry, the *Tfp* is parallel to the gelatinizing temperature (the change from sol to gel), and the dependence of glass properties on thermal history (Eckert, p. 219) would be parallel to the hysteresis phenomena (Banerji, Lederer) of a gelatinous solution (see footnote 12). There are a number of differences, however, which warn us to be careful in carrying these analogies from colloidal chemistry too far into glass problems. For instance, a viscous glass of a chemically homogeneous substance would represent a particular sort of a colloidal solution in which the disperse phase and the dispersing medium have the same analytical chemical composition. Such systems have been called iso-colloids. Thus, swelling or dissolving of polystyrol by styrol is obviously different from simple heating of a polystyrol glass above the *Tfp*. This difference can be explained by assuming different concentrations of the disperse phase and, according to this, glasses must be a highly concentrated, iso-disperse system in dynamic equilibrium, different from ordinary (dilute) colloid solutions such as are usually dealt with in colloidal chemistry.

A certain justification of the colloid chemical conception of glass may be obtained from the following observations: If a quantity of quite fluid glass is taken from a tank or pot, it appears reddish turbid, and non-transparent, but, on cooling, as it approaches the *Tfp*, it turns into a clear transparent substance. This phenomenon can be clearly observed in lead- or barium-containing glasses, but not so easily in ordinary plate glass. This turbidity can be more easily observed and for a longer time when a pot of optical glass at about 1000° is taken out of the pot arch and allowed to cool in air. On the other hand, in a tank which contains well-annealed, iron-free glass at 1000°, the glass-covered bottom tank blocks can be clearly seen through the glass just as though the liquid glass were clear water.

This observed turbidity is similar to many colloidal solutions and might be explained by the fact that, because of rapid cooling, equilibrium is not established between secondary particles and the dispersing medium, but that actually a dilute colloidal solution exists with large differences of refractive index between the phases.[14] At any rate these observations point out the possibility that viscous glass is of heterogeneous composition. There are still differences of opinion as to whether or not a gel is a two-phase colloidally dispersed heterogeneous system. We shall see that the conception of a brittle glass as a two-phase heterogeneous body is of significance in

[14] For instance SiO_2-polymers in a lead-barium silicate liquid. The results of Fulcher make it probable that CaO and other bi- and tri-valent oxides join with SiO_2 groups only below a certain temperature (aggregation point), forming complex particles, thus wiping away the differences in refractive index. Cooling down quickly, this formation of complex particles may be checked (compare Stott).

kinetics of aggregation processes; it agrees with Filon's interpretation of piezo-optical measurements.

Mixed glasses have been looked on as forming multi-phase systems. It has, however, been proved in the case of polymerization (Wagner-Jauregg) as well as of association (for instance, in a mixture of dipole-liquids) that aggregation does not form different kinds of particles arranged side by side, but rather builds them up in uniform groups according to certain structure principles.[18] The primary and secondary particles hence can combine some or all of the components of the mixture into complex particles of the same kind. A picture of the detail structure of complexes as an example is given by Bragg in a model of beryl. This is a first step in the solution of the problem mentioned in the introduction as to why a homogeneous substance behaves in the same peculiar way as a mixture such as an industrial glass during transition from liquid to glass (compare Berger (VI), p. 594).

Colloid chemistry assumes that while warming a colloidal system such as a gelatinous gel, the complex colloidal particles dissociate, but that if severe changes are avoided, the process will remain reversible and this splitting up can only go down to the formation of micellae, as they are called by Naegeli (Thiessen, p. 435). These micellae are believed to be crystallites having a lattice structure. I consider it more appropriate to reject the term "crystallite" in describing an individual micella; because of its remarkable stability it had better be described as a three-dimensional macro-molecule or primary particle. In this way, at least, we obtain an understanding of more recent X-ray investigations (Randall (I, II); see also Gottfried and Drucker (II)) of glasses and other liquids which show that more than 90% of them are built up out of tiny crystallites; still they do not represent crystalline products but rather show properties such as those previously discussed.

With probable justification, Prins (I, II) calls it naïve to consider a liquid as an unsuccessful imitation of crystalline lattice formation. Prins (I) shows very instructively that a pile of seed grains which certainly would not be considered to be modeled after a crystalline substance, follows a law of distribution for the distance between the grains, which in the language of X-ray photography would mean a regularity of arrangement. According to Thiessen a micella in a sodium oleate (soap) solution is composed of more than 100 molecules in a regular space arrangement and yet it acts at the same time not as a crystal nucleus but forms secondary particles by association, this dynamic aggregation leading to the formation of a glassy gel. Crystallization, occurring sometimes in the same solution, depends on the arrangement of the micellae and one is led to believe that a

[18] Compare X-ray proof by Meyer, that in a mixture of liquids only one kind of aggregates (called cybotactic groups) is present.

crystal nucleus is formed only by a definite arrangement of several "micels" (compare Jander (II) and Krause).

This problem, stimulated by X-ray investigations, leads to the question of what a micella, or, according to our point of view, a large macromolecule or primary particle is, and under what conditions it exists. Ostwald (I, II) suggests a solution in which the elementary cells of a crystallized material, as found in X-ray pictures, are combined until the particle produced has the same chemical composition as found by analysis. This is not generally true of an elementary cell. In this way Ostwald computes particle sizes of colloidal dimensions such that all valences are satisfied. It will only be pointed out here that, according to recent theory, crystals are not composed of individual molecules but rather of molecular groups, lattice blocks, or larger submicrons (see the hypothesis of mosaic structure of crystals by Zwicky, and that of the stability of the submicron during the formation and solution of crystals by Traube). We recognize therefore that the general theory of aggregation dynamics can be the foundation not only of the theory of liquids and of glasses but also of the crystalline state, and that it may also be of importance in regard to the mechanical properties: plasticity, deformation by cold working, recrystallization, and other questions.

VI. Kinetics of Aggregation

A further insight into the phenomena of aggregation should be possible from the point of view of aggregation kinetics, *i.e.*, a discussion of the speed of equilibrium attainment in going from one temperature to another. In

TABLE III

EQUILIBRIUM DISPLACEMENTS FROM REFRACTIVE INDEX MEASUREMENTS

(Glass BaLK 3; pre-treatment 30 min. at 520°C; annealing temp. 440°C)

Total annealing time (minutes)	n		$(n-a) \times 10^5$		Log $(n-a) \times 10^5$		Log z
0	1.51712 = a						
5	1.51712		0		(0)		0.700
15	1.51743		31		1.490		1.176
35	761		49		1.690		1.544
75	784		72		1.857		1.875
155	811		99		1.996		2.191
315	834		122		2.086		2.498
600	843		131		2.117		2.778
1200	869		157		2.196		3.079
2400	865	1.51870	153	158	2.185	2.198	3.380
3600	874		162		2.210		3.556
6000	865		153		2.183		3.778

this case I must again restrict myself to a short sketch and leave more thorough treatment to further investigations and a later paper.

It has been found that the formation of primary particles, that is, aggre-

gation (polymerization) of individual molecules by chemical bonds into fibers, plates, or three-dimensional structures, is a first order monomolecular reaction (see Tammann, VIII). This means that the rate of increase in concentration, c, of primary particles (dc/dz) is proportional to the concentration at any time, z, of only one kind of molecules (in this case the monomerides, the components of the polymers). Other properties, such as the volume (dv/dz), change in direct proportion to the concentration of primary particles. If the starting number of monomerides, or the initial volume, is equal to a, it follows from the equation, $\frac{dc}{dz} = k(a - c)$, that log $(a - v) = k \cdot z + C$, *i.e.*, the logarithm of the property change is a linear function of the time. Tammann (VIII) and others verified this relation through polymerization experiments. The fact that primary particle reactions are not reactions of a higher order can be explained by assuming that some process other than the mere aggregation of many particles is the reaction-velocity determining factor. According to Staudinger (II), this important process can consist, in the case of styrol, in a loosening of the double bond, *i.e.*, in an activation. After loosening the double bond a combination of the various molecules takes place rapidly.

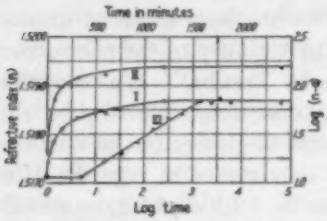

FIG. 15.—Changes of refractive index with time and log time.

According to present knowledge, the shift of equilibrium in the glassy or viscous state, dealing chiefly with secondary particles, follows a still different law. In this case the logarithm of a property value is not a linear function of the time as shown in Fig. 15, representing arbitrarily selected values of equilibrium adjustments of the refractive index.

The experiment was carried out as follows (see Berger (IV)):

A polished sample taken from a melt of optical glass (BaLK 3) was heated in an electric furnace at 520° for 30 minutes and then quenched. According to previous experience only 5 to 10 minutes are necessary for the establishment of equilibrium at this temperature so that the measured refractive index, $a = 1.51712$, after quenching, surely represents the equilibrium value for 520° at room temperature. This treated glass was now annealed at 440° for various times as shown in Table III. After each quenching the refractive index values shown in Table III were obtained.

As is seen, annealing for five minutes did not change the refractive index; perhaps this is because of a certain induction period or because the annealing temperature was not reached quickly enough. After heating ten minutes longer (total annealing time is now fifteen minutes), the refractive index is markedly increased and this process continues until at about 1200

minutes, a constant end value of 1.51870 was reached. Curve I of Fig. 15 shows the changes thus found in n; curve II shows the change of log $(n - a)$ with time, z, where a represents the initial refractive index. It is here seen that the logarithm of the property change is not proportional to time so that this shift of equilibrium can not be considered as a monomolecular, first order reaction.

On the other hand, in curve III, refractive index n plotted against log time gives a straight line, *i.e.*, $n - a = k$ (log z − log i), in which the i represents the induction period. Differentiating this equation, we get $\frac{dn}{dz} = \frac{K}{z}$, and recognize that the rate of establishment of equilibrium in the brittle state is an inversed monomolecular reaction. Even though, according to several further examples shown in Fig. 16 (see also Berger (IV), p. 347), this inverse law of reaction velocity is accurately followed in a chemical change or at least one involving heat effects (see Fig. 7), a theoretical interpretation of such a reaction does not seem to be possible according to physical-chemical principles. But there is another interesting field which can only be described by a similar reaction velocity. I am referring to laws of elastic after-working (Nachwirkung).

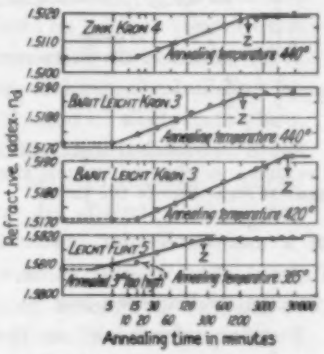

FIG. 16.—Shift of refractive index toward the equilibrium value N plotted against log time.

A glass fiber is well known to undergo an elastic deformation under load (the same applies to certain metallic and other fibers)[16] and this is followed by a reversible further elongation called elastic after-working or after-effect which slowly decreases with time (z). (The possibility of flow or irreversible plastic deformation under load is not considered here.) This additional increase in length follows the same law, *viz.*, the elongation is proportional to log z. This result is not surprising because of the similarity between the dependence of elastic after-working on the mechanical history in the one case and the dependence of thermal after-working or establishment of equilibrium on thermal history in the other case. If, as previously worked out, temperature change in a glass implies a reduction or an increase in the size of the secondary particles, it appears obvious that in the elastic case of plastic after-working similar processes may result from tension or pressure forces.

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[16] Previous literature on elastic after-working has been gathered together by Auerbach. Philipps and also Joffe have carried out careful investigations on filaments of glass, metal, and rubber. For more recent references see Becker, Schlechtweg, and Sayre.

By chance I notice a further parallel which may throw light on this problem. A paper by Tamaru on the thermal dissociation of calcium carbonate describes an apparatus in which, in an enclosed volume, the CO_2 pressure, P, and the mass, G, of the $CaCO_3$–CaO mixture may be simultaneously and continuously determined under constant temperature conditions. The gas pressure was suddenly reduced in one experiment and the resulting dissociation was then measured as a function of time by weighing and reading the manometer. The results are graphically shown in Fig. 17 (curves I and II). Curve I shows the mass of the lime mixture, and curve II, the CO_2 pressure plotted against time. It is noteworthy, even more definitely than in Fig. 15, curve I, that at a certain time equilibrium is suddenly attained. The log of the pressure increase or of the decrease in mass plotted against time does not give a straight line, in correspondence with Fig. 15, *i.e.*, the law is not that of a monomolecular reaction. On the other hand, curves III and IV of Fig. 17 show P and G as a function of log z, accurately checking the previously discussed law.[17]

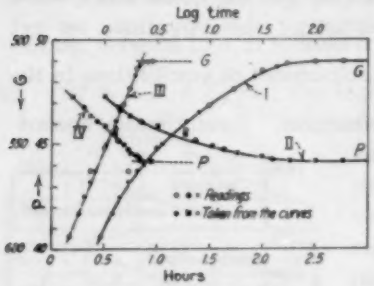

FIG. 17.—Dissociation of $CaCO_3$ with the time; weight and volume changes against logarithm of the time.

Further references[18] in the literature indicate that the mechanism of reactions in a heterogeneous system can be described by a law involving "log z." It is in fact not surprising that the kinetics of homogeneous and heterogeneous systems are different. There is a fundamental difference between them in that in the first case equilibrium depends on the concentration of the reacting substances, and in the latter case equilibrium is independent of what actual quantity of each phase is present. A dimen-

[17] When dissociation of calcium carbonate takes place with atmospheric pressure and not in an enclosed volume by passing an air stream over the carbonate, Maskill finds for the increase in rate of dissociation, α, with time, z, that the formula, $\log \alpha = k \log z + C$, is followed very well. The simpler law, $\alpha = k \log z + C$, can be deduced from experiments by Grube (p. 85) and by Stumper.

[18] According to Slonim, p. 445, the velocity of thermal decomposition of $CaCO_3$ ($d\alpha/dz$) is inversely proportional to the time. According to Sameshima, the rate of absorption of gaseous ammonia by mineral silicates such as chalcedony, opal, and natural silica gel, capable of absorbing considerable amounts, can be represented by the equation $x = k \cdot \log z + C$, where x is the absorbed mass at the time z, and k and C are constants. Reichinstein shows that certain absorption processes must be represented by a "log z" law. Von Steinwehr (p. 532) indicates similar changes in the electromotive force of a Weston cell. Unfortunately, I have not yet been able to find more complete numerical data. It is, however, desirable that this particular velocity law and its significance be carefully investigated because textbooks on physical chemistry at present contain nothing on the subject. See for instance Nernst, page 668. Hess exhibits the difficulties which arise in describing the kinetics in heterogeneous systems by the usual formulas.

sional analysis even shows that the velocity of property changes should be inversely proportional to time, which means that when the concentration of a constituent (or a property value) has no influence, the "log z" law is to be observed.

It is certainly necessary to await further experimental proof before definitely concluding that, because of the validity of the "log z" law, brittle and viscous glass should be represented as a heterogeneous (two-phase) system, whose properties are determined by a "dissociating pressure" which changes with the temperature.[19] Similar conditions exist in a system of undissolved solid particles in equilibrium with a saturated solution, this picture of heterogeneous systems leading to the colloidal conception that glasses and viscous liquids consist of a disperse phase (secondary particles) embedded in a concentrated solution of primary particles as the dispersing medium.[20] Our considerations thus lead us back to those of the previous chapter and it would no doubt be stimulating to examine other phenomena from this point of view (elastic after-working, the building up of block structure in crystalline materials, penetration of silver into glass, increase in alkali on the surface of silicate glasses by heat treatment, etc.). I wish to show briefly in conclusion how these theoretical considerations can be applied to practical problems in industry by slightly shifting the point of view.

The question of how long it is necessary to anneal glass to eliminate strain or double refraction caused by rapid cooling belongs in the field of aggregation kinetics. This question is usually approached from a point of view that mechanical pressure and tension forces bring about double

[19] Compare relations between fluidity (or viscosity) and the vapor pressure of liquids (Drucker (I)).

[20] In preparing the printing of this paper, I realized that a theoretical meaning can be given to the log z law by v. Smoluchowski's theory of coagulation kinetics in colloidal solutions. Von Smoluchowski determined by calculation the number of single primary particles ν_1, of double particles ν_2, triple particles ν_3, etc., which are present at a given time, z, in the coagulating solution, the concentration in primary particles at the beginning of coagulation being ν_0. It follows that (i being a constant time)

$$\nu_1 = \frac{\nu_0}{\left(1+\frac{z}{i}\right)^2} \text{ and } \Sigma\nu = \nu_1 + \nu_2 + \nu_3 + \ldots = \frac{\nu_0}{1+\frac{z}{i}}$$

If the change of property value, dP, by the aggregation process which appears to be similar to coagulation in a colloidal solution, is proportional to the ratio $\frac{\nu_1}{\Sigma\nu}$, *i.e.*, with glasses the concentration in primary particles, we get

$$\frac{dP}{dz} = f \cdot \frac{\gamma\nu}{\Sigma\nu} = \frac{f}{1+\frac{z}{i}}$$

or by integration $P - P_0 = f \cdot i \cdot \log\left(1+\frac{z}{i}\right) = k[\log(z+i) - \log i]$, this being practically the same formula arrived at by the above-mentioned experiments.

Tammann (IX) stated that for the formation of oxidized films on a polished metal plate by action of air the same formula agrees with experiments.

refraction and that they cause internal flow phenomena in addition to elastic changes and elastic after-working already spoken of. Equating the strain due to thermal and mechanical causes leads to the assumption that while cooling, tensions are released by a flowing of the glass (Adams). The viscosity of a glass at a particular temperature thus appears as a measure of this annealing speed. A recent paper by Sharp serves to emphasize this relation between thermal and mechanical stresses.

According to Maxwell, internal flow in a viscous body is such that the rate of release of strain is proportional to the stress. Investigations of Adams do not agree with this relation similar to that for a monomolecular reaction. It is therefore assumed that the rate of annealing is proportional to the square of the strain though this assumption has no physical basis and is only of restricted validity (Berger (IV, V)). This is not surprising, however, when we consider the evidence of Fig. 6, according to which the viscosity will not remain constant[21] during the annealing of a quenched glass. The reason for the square law of Adams is obviously that the viscosity change is assumed to be proportional to the strain. Our previous developments have attributed viscosity changes as well as volume and refractive index changes at a given temperature to inner displacements of state varying only with time[22]; so we are getting closer to being able to explain annealing processes without considering internal flow phenomena. It has actually been shown (Berger (IV, V)), that changes in double refraction with time of cooling can largely be explained by the assumption that during chilling the glass attains various states of aggregation according to the temperature differences between the outer and inner layers. The differences in volume established in this way call for double refraction and disappear according to a mathematical law depending on "log z"; this has largely been verified by the results of these experiments (Berger (IV, V)).

Even though in general actual flow phenomena need not necessarily take place during annealing, flow may possibly occur in certain cases. Experiments by Russ (p. 535) show that when cool glass at 750°C is quickly covered by hot glass at 1200°C (thermal streaks), the strain caused by this welding is harder to get rid of than in the case of a single chilled piece of

[21] A communication from Dr. Thomas gives much unpublished data on experiments verifying this. Sharp, Lillie, and others also give indications that viscosity depends on thermal history (see Berger (IV), p. 364).

[22] The validity of the "log z" law is easily shown by a curve (Rebbeck, p. 331) on electrical resistance (log W).

McMillen recently stated that viscosity (η) changes of thixotropic materials (paints) obey a similar law: $\log \eta = k \log (z + a) - C$ (thixotropy is a reversible sol-gel transformation caused by mechanical disturbance).

The deduction of the "log z" law from v. Smoluchowski's theory given in footnote 20 leads to the same formula, regarding $\log \eta$ to be proportional to concentration (Arrhenius: for literature see Freundlich, p. 540); this leading to the equation $\frac{d \log \eta}{dz} = f \cdot \frac{p_1}{\Sigma p}$, etc.

glass which has the same initial strain or double refraction (see also Berger (IV), p. 356 and *Glastech. Ber.*, **10**, 16 (1932)). If, according to Sharp, mechanically and thermally induced strain can be released in the same way, it should be noted that bending stress causes phenomena in the following order of time: elasticity, elastic after-working, and then flow, and these phenomena may be assumed to be in the opposite order when stress is released. Since elastic and thermal after-working, as shown, follow the same "log z" law, the observations of Sharp are not surprising. Sharp's arrangement, however, offers the possibility of studying the relations between thermal and elastic after-working, and in this way we may penetrate more deeply into the problem.

No doubt many points of the previous discussion may be regarded as uncertain knowledge, but I have not been afraid to discuss them here for the purpose of obtaining a well-rounded picture of the theory of glass formation and the glassy state despite the gaps which are evident. Many problems have been scarcely touched, but they show that these theoretical developments may be of importance not only to glass research, but also of significance in regard to liquids and to the crystalline and colloidal states. It is not surprising to find the glassy state and its analysis in the center of the picture. The gaseous and the crystalline states of matter are the only states about which much is known. The structure of liquids is a separate problem which has only recently been touched. If investigation is limited to crystallizing substances, the temperature region in which measurements are available is further limited. The glass-forming substances in which the disturbances and limitations of crystal formation are not present are far more suitable.

If the fields of physics and chemistry and particularly of colloid chemistry can be made conscious of the general importance of glass research and of glass not being a haphazard product inaccessible to science, and if experimental and theoretical men of all countries interest themselves in the problem of adding knowledge of the glassy state to the scientific knowledge of the world, then it should soon be possible that the many thousand year old glass technology will develop into a science on the basis of which much progress will be made.

APPENDIX

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Journal *of the* American Ceramic Society

VOLUME 15, 1932

A Monthly Journal Devoted to the Arts and Sciences Related to the Silicate Industries

Editorial and Advertising Offices: 2525 North High St., Columbus, Ohio.

Publication Office: 20th and Northampton Sts., Easton, Pa.

Editor: Ross C. Purdy; *Assistant Editor:* Emily C. Van Schoick.

Committee on Publications: J. T. Littleton, *Chairman,* M. F. Beecher, Louis Navias, L. J. Trostel, Ross C. Purdy.

CERAMIC ABSTRACTS[1]

Compiled by the

AMERICAN CERAMIC SOCIETY

ROSS C. PURDY, Editor

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Vol. 11 **December, 1932** **No. 12**

Abrasives

Centerless grinding troubles corrected. A. D. MEALS. *Abrasive Ind.*, **13** [10], 9–10 (1932).—With through-feed grinding, taper on the front end is caused by the guide plate on the regulating-wheel side of the through-feed work rest block being set back from the face of the regulating wheel on the entering side. This allows the entering end of the work to be moved into the face of the grinding wheel as it enters the grinding cut, thus grinding the front end tapered. It is corrected by setting the guide plate to line up exactly with the face of the regulating wheel. Taper on the rear end of the work is remedied similarly. Chatter is caused by (1) maladjustment of grinding wheel or regulating-wheel spindle, (2) too steep an angle on the work-support blade, (3) thin work-support blades, (4) grinding too high above center, and (5) too hard or too fine grained a grinding wheel. Removal marks on work can be remedied by dressing the face of the grinding wheel to a slight taper from the exit edge, *i.e.*, the open end of the taper toward the rear or leaving side of the wheel. As a piece of work is being ground, the grinding cut will stop at a point when the work is about $^1/_2$ in. from the rear edge of the grinding wheel. A slight polishing action will thus be given to the work. E.P.R.

Grinding the liners of I. C. road engines. R. WAKE. *Mech. World*, **92** [2382], 201–203 (1932).—W. deals with the renewal and grinding of engine liners. The methods and data given are representative of the latest practice in the maintenance of large fleets of commercial vehicles. E.P.R.

Crankshaft grinding machines. CHURCHILL MACHINE TOOL CO., LTD. *Mech. World*, **92** [2382], 197 (1932).—Simplified machines for light work are described. Grinding can be done by the plunge-cut method, but a limited table movement is provided. Important features are the single lever control and a sizing device which does not disengage the feed abruptly but diminishes it at a uniform rate. E.P.R.

Improved 12-inch grinding machine with hydraulic traverse. CHURCHILL MACHINE TOOL CO., LTD. *Mech. World*, **92** [2380], 156 (1932). E.P.R.

Reducing polishing expense. EDWARD S. HECK. *Abrasive Ind.*, **13** [10], 15–17 (1932).—When the ordinary precautions are observed in glue preparation and application the full benefits of the best drying practice can be obtained. Soak the glue in cold, clean water. Prepare no more glue at one time than can be used immediately. Keep the temperature of the heated glue below 150 °F. The shorter the length of time the glue is held under heat the stronger it will be. Keep the brushes and pots clean as a small amount of old glue will spoil a new batch. Heat the wheel and abrasive to approximately 110 °F before setting up. Do not allow the wheel, the glue, or the abrasive to be chilled during application. Continued cooking at high temperatures disintegrates glue. The room used for setting up the wheels should be protected from cold drafts. It is common practice to keep the pans of abrasive over a section of steam pipes so that it is warm when the wheel is rolled in the pan. The wheel should be warm when the glue is applied. E.P.R.

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[1] The abbreviation (*C.A.*) at the end of an abstract indicates that it was obtained from *Chemical Abstracts* by coöperative agreement.

The bold-face number following the journal name is the volume, the issue number is in brackets followed by the page numbers, then the year in parentheses.

Polishing for artistic effects. ANON. *Abrasive Ind.*, **13** [10], 14 (1932). E.P.R.

Federal specifications for aluminum oxide abrasive cloth. ANON. *Abrasive Ind.*, **13** [10], 13–14 (1932).—The Federal Specifications Board, Washington, is adopting and promulgating purchase specifications for commercial commodities purchased by the various departments and establishments of the U. S. government. The specifications on aluminum oxide abrasive cloth are given. E.P.R.

Lapped valves to insure perfect seating. PIERCE ARROW MOTOR CAR CO. *Abrasive Ind.*, **13** [10], 11–12 (1932). E.P.R.

PATENTS

Valve-seat grinder. H. M. ALBEE (Leavitt Machine Co.). U. S. 1,877,782, Sept. 20, 1932.

Honing machine. A. M. JOHNSON (Barnes Drill Co.). U. S. 1,877,881, Sept. 20, 1932.

Sharpener for slicing machines. C. F. M. VAN BERKEL (U. S. Slicing Machine Co.). U. S. 1,878,066, Sept. 20, 1932.

Ring-grinding machine. FRITZ DEUTSCH (Lehmann Machine Co.). U. S. 1,878,116, Sept. 20, 1932.

Tool-grinding machine. J. M. DOEBRICH. U. S. 1,878,385, Sept. 20, 1932.

Lapping machine. A. E. ROBINSON (American Tool Works Co.). U. S. 1,878,603, Sept. 20, 1932. HARRY BLOUNT (Western Electric Co., Inc.). U. S. 1,880,729, Oct. 4, 1932.

Grinding-wheel dresser. H. H. DOVELL, R. S. MCCONNELL, AND HENRY HENZ (Desmond-Stephan Mfg. Co.). U. S. 1,878,763, Sept. 20, 1932.

Abrading apparatus. SEBASTIANO MAGNANO (Magnano Corp.). U. S. 1,878,791, Sept. 20, 1932.

Method of lapping gear sets. J. M. CHRISTMAN (Packard Motor Car Co.). U. S. 1,879,089, Sept. 27, 1932.

Grinding. R. H. CRAMER (General Motors Corp.). U. S. 1,879,110, Sept. 27, 1932.

Cylindrical grinding attachment for surface grinders. W. L. DOLPH AND N. H. LEWIS. U. S. 1,879,134, Sept. 27, 1932.

Buffing machine. A. S. JOHNSON AND H. W. NEUNHERZ (Gem Crib & Cradle Co.). U. S. 1,879,286, Sept. 27, 1932.

Indexing means for grinding milling cutters. G. E. MIRFIELD. U. S. 1,879,399, Sept. 27, 1932.

Grinding machine. L. L. ROBERTS (Packard Motor Car Co.). U. S. 1,879,506, Sept. 27, 1932. CLEMENT BOOTH AND F. S. HAAS (Heald Machine Co.). U. S. 1,880,-736, Oct. 4, 1932.

Dressing mechanism. E. W. BULLOCK AND H. J. WHITE (Gleason Works). U. S. 1,880,234, Oct. 4, 1932.

Method of grinding bearing races. K. L. HERRMANN (Bantam Ball Bearing Co.). U. S. 1,880,347, Oct. 4, 1932.

Valve-grinding means. H. I. DYER (Wilcox-Rich Corp.). U. S. 1,880,377, Oct. 4, 1932.

Work table for grinding machines. JOHN BATH. U. S. 1,880,673, Oct. 4, 1932.

Multiple grinder. C. T. RAULE. U. S. 1,881,244, Oct. 4, 1932.

Abrasive coated materials. W. J. TENNANT (Behr-Manning Corp.). Brit. 379,379, Sept. 7, 1932.

Rail-grinding machines. C. P. HOPLEY. Brit. 379,393, Sept. 7, 1932.

Grinding gear wheels. DEUTSCHE NILES WERKE AKT.-GES. Brit. 379,691, Sept. 14, 1932.

Method and apparatus for lapping gears. L. MELLERSH-JACKSON (National Broach and Machine Co.). Brit. 379,837, Sept. 14, 1932.

Segmental grinding wheels. NORTON CO. Brit. 380,086, Sept. 21, 1932.

Apparatus for grinding, surfacing, and polishing the surfaces of lenses, etc. A. PASS. Brit. 380,231, Sept. 21, 1932.

Art and Archaeology

Further work in the experimentation and application of underglaze color crayons. KENNETH E. SMITH AND WILLIAM STEVENS. *Jour. Amer. Ceram. Soc.*, **15** [11], 630–31 (1932).

Color facts for the manufacturer. WILLIAM J. MISKELLA. *Better Enameling*, **3** [4], 8 (1932).—M. discusses color and defines hue, brightness, and strength which are the

three terms necessary to describe any color completely. He illustrates, by means of figures, the relative positions of the primary, secondary, tertiary, quaternary, deep gray, and black colors, and also of tints and shades. Color combinations and the effects of various colors are discussed. W.W.M.

Market for art pottery broadened by model service. ARTCRAFT STUDIOS. *Ceram. Ind.*, **19** [4], 194 (1932).—A service for supplying high-quality models for profile and relief decoration on lamp bases and other artware has been established under the name of the Artcraft Studios, Oak Park, Ill. W.W.M.

The expedition to Ctesiphon, 1931–32. JOSEPH M. UPTON. *Bull. Met. Mus. Art*, **28** [8], 188–97 (1932).—Among the pottery finds at Ummez Za'tir is a jar $12^1/_2$ in. high with a Sasanian blue-green glaze. The form of an interesting unglazed ewer is characteristic of Sasanian metal work. Plain glass bottles, glass fragment with pressed decoration, and small terra cotta figures were also found. A.A.A.

A recent acquisition of Persian ceramics. M. S. DIMAND. *Bull. Met. Mus. Art*, **27** [6], 159–61 (1932).—Three masterpieces recently acquired from the collection of the late V. Everit Macy rank high among products of Persian potters of the 12th and 13th Centuries. A graceful jug with pierced decoration from Sultanabad, covered with turquoise blue glaze, has an interesting inscription which is dated. The combination of modeling, cutting, painting, and glazing shows great technical proficiency. A plate and a large bowl are other examples of Persian luster technique. See also *Ceram. Abs.*, **10** [9], 622 (1931). A.A.A.

Discoveries at Nineveh. R. C. THOMPSON. *Illus. London News*, **181**, 98–99 (1932).—The earliest fragments of painted pottery go back at least to 5000 B.C. 11 photographs. See also *Ceram. Abs.*, **11** [4], 223; [9], 479 (1932). H.H.S.

BOOKS

A Guide to the Islamic Pottery of the Near East. R. L. HOBSON. xvi + 104 pp. 39 plates. British Museum, London, 1932. Price 2s. Reviewed in *Times Lit. Supp.*, **31**, 517 (1932); see also *Ceram. Abs.*, **11** [11], 550 (1932). H.H.S.

The Pan Painter. J. D. BEAZLEY. Keller, Berlin, 1932. Price 32Rm. Reviewed in *Times Lit. Supp.*, **31**, 530 (1932).—The Pan painter was so named from a vase of the 5th Century B.C. found at Cumae which is now in the Boston Museum. H.H.S.

PATENTS

Design for bottle. E. W. FUERST (Owens-Illinois Glass Co.). U. S. 87,777, Sept. 20, 1932, and 87,834, Sept. 27, 1932. W. J. POPP. U. S. 87,853, Sept. 27, 1932. J. J. QUINN (Pinaud, Inc.). U. S. 87,854, Sept. 27, 1932.

Design for cover glass lens for headlights. G. A. M. LAMBLIN-PARENT. U. S. 87,842 and 87,843, Sept. 27, 1932.

Design for decanter, etc. W. C. MCCARTNEY. U. S. 87,846, Sept. 27, 1932.

Design for refrigerator casing. J. K. OLSEN (Stewart-Warner Corp.). U. S. 87,882 and 87,883, Oct. 4, 1932.

Design for cook stove. G. E. PICKUP (Wehrle Co.). U. S. 87,884 and 87,885, Oct. 4, 1932.

Cements

Analysis of standard cements. H. BURCHARTZ. *Zement*, **20** [46], 987 (1931); abstracted in *Chim. & ind.*, **27** [4], 845 (1932).—The commission charged to revise the analytical methods used for examining cements suggested the following method for determining alkalis. The silica is precipitated by means of a single evaporation of the hydrochloric solution. The filtrate is treated with ammoniac and ammonium oxalate to separate the metallic oxides and lime. This treatment is repeated after filtering and concentration so that the final filtrate is deprived of heavy metals. The liquids obtained from the 2 tests made with 1 g. of cement are brought together and evaporated until the disappearance of the ammonium salts. Some water is added to the residue and 10 cc. of a 4% baryta solution are added cold. It is filtered after 30 minutes and washed 3 times with a baryta solution; the barium in the filtrate is precipitated with ammonium carbonate. Barium carbonate is filtered after ebullition and decantation and washed. The filtrate is evaporated in a steam bath and the residue, after being heated to 130°, is moistened with a hydrochloric solution; the amount of chlorides is weighed after eliminating the hydrochloric surplus. By multiplying the weight by 0.6317, the quantity of alkalis expressed in K_2O is found. In case it is necessary to

know the relative proportion of Na_2O and K_2O the procedure is as follows: The chlorides are dissolved in water and the solution is evaporated in the presence of perchloric acid. The HCl is expelled by treating the residue with water and evaporating to dryness. This is repeated several times. The final residue is cooled, some alcohol and perchloric acid are added, and potassium perchlorate is filtered. It is washed with alcohol, dried at 130°, and the perchlorate is weighed. See also *Ceram. Abs.*, **11** [2], 79 (1932). M.V.K.

Comparison of the fineness of two series of cements ground by two methods. KATSUZO KOYANAGI. *Rock prod.*, **35** [17], 26 (1932).—K. states that there are two processes for fine grinding of cement, (1) by short mills with an air separator and (2) by long mills without an air separator. He conducted tests and presents the results shown in the table. The inadequacy of sieve analyses is pointed out.

CEMENT GROUND BY SHORT MILLS WITH AIR SEPARATOR

Sample No.	Size of mills (ft.)	Diam. of separator (ft.)	Fineness of Cement: Sieve test 4900/cm.²	Residue on 10,000/cm.² (%)	Air Analysis: Residue (%) at air pressure of 70 mm.	50 mm.	35 mm.
1	7x24 (2-chambered)	14	1.2	5.3	25.2	29.3	33.4
2	7x11 (2-chambered)	14	1.2	9.3	28.8	31.6	37.0
3	7x26 (2-chambered)	14	1.6	5.9	28.0	33.2	37.4
4	7x22 (2-chambered)	14	1.6	7.8	30.1	35.0	38.2
5	7x24 (2-chambered)	14	1.6	8.1	37.8	42.2	52.2
6	7x26 (2-chambered)	9	3.0	9.3	31.4	34.4	38.4

CEMENT GROUND BY LONG MILLS WITHOUT AIR SEPARATOR

Sample No.	Size of mills (ft.)	Fineness of Cement: Sieve test 4900/cm.²	Residue on 10,000/cm.² (%)	Air Analysis: Residue (%) at air pressure of 70 mm.	50 mm.	35 mm.
7	7x36 (3-chambered)	1.0	4.0	17.4	19.0	22.6
8	7x36 (4 ")	1.5	4.7	19.4	23.4	27.2
9	7x36 (3 ")	1.8	6.12	19.6	24.4	27.0
10	7x36 (4 ")	2.5	9.4	24.5	29.8	33.8

W.W.M.

Setting and hardening of cement. Q. SESTRINI. *Z. angew. Chem.*, **45** [35], 564 (1932).—S. studied the processes of setting and hardening by observing microscopic slides. He concludes that these processes are colloidal phenomena. On the addition of SiO_2 from the Blanc process to mortars, the strength is improved. Such cements are more resistant to corrosion than those without additions. L.T.B.

Determination of free lime in cement. N. A. TANANAEV AND L. M. KULBERG. *Z. anal. chem.*, **88**, 179–83 (1932); *Analyst*, **57**, 477 (1932).—The method is based on the following reaction in alcoholic solution: $HgCl_2 + CaO + 4KI + H_2O = CaCl_2 + 2KOH + K_2HgI_4$. H.H.S.

Manufacture of high-quality cement. T. KLEHE. *Tonind.-Ztg.*, **56** [70], 876–78 (1932).—Different crushing machines are described. Proposals for improving the quality of the cement and reducing the temperature of sintering are discussed. See also *Ceram. Abs.*, **11** [5], 292; [9], 480 (1932). W.M.C.

Volume stability of magnesium oxychloride cement. A. KRIEGER. *Tonind.-Ztg.*, **56** [68], 848–49 (1932).—Experiments show that a small amount of magnesium chloride, low firing temperature of the magnesite, small particle size, and a high temperature during the setting of the magnesium oxychloride cement are the reasons for the shrinkage or decrease in the expansion observed. During setting the formation of $Mg(OH)_2$ is completed fast enough to reduce the oxychloride reaction. W.M.C.

Kaolin as a raw material for the cement industry. W. OHLENDORF. *Tonind.-Ztg.*, **56** [76], 946–47 (1932).—The use of kaolin as a raw material to replace bauxite in cement is found to be unfeasible. W.M.C.

Ferrous oxide content in clinker of a friable cement. K. KOYANAGI. *Zement*, **20** [53], 1098–99 (1931); abstracted in *Chim. & ind.*, **27** [4], 1098 (1932).—It is supposed that the friability of clinker is due to the presence of a certain proportion of ferrous oxide and metallic iron. K. analyzed such clinkers and found that they were composed

of 3 fractions, (1) a dark fritted fraction of a bluish color, (2) a hard melted fraction of dark brown, and (3) thin dust. The analysis of the last showed hardly any ferrous oxide in contrast with the other fractions. K. concludes that the presence of ferrous oxide in a clinker does not necessarily determine its friability. M.V.K.

Hydrated lime aluminates and their rôle in the setting of cement. Resistance of sulpho-aluminate to water-containing sulphates. A. TRAVERS. *Chim. & ind.*, **27** [4], 755–64 (1932).—"Ciment fondu" dissolves at first in the form of monocalcium aluminate producing a supersaturated solution. This unstable solution deposits with $21H_2O$ hydrated crystals of tricalcium aluminate, after which crystals of alumina and hexagonal basic aluminates are formed through hydrolysis. It must be assumed that the setting finally leads to a mixture of crystals of alumina and hexagonal basic aluminates with a large superficial development. T. found that sulpho-aluminate of lime is resistant to saturated solutions of lime, calcium sulphate, magnesium sulphate, and ammonium sulphate, but not to saturated solutions of potassium and sodium sulphate. M.V.K.

Experiments on the hydrothermal synthesis of calcium hydro-aluminates. S. NAGAI. *Z. anorg. allgem. Chem.*, **207** [3], 313–18 (1932).—Compositions of CaO, Al_2O_3, and H_2O were placed in a nickel crucible in an autoclave at 152 to 154° for one day. They were then kept in a desiccator until constant weight was assumed and subsequently analyzed. The following compounds are reported: $3CaO \cdot Al_2O_3 \cdot 6H_2O$, $2CaO \cdot Al_2O_3 \cdot 7H_2O$ or $2CaO \cdot Al_2O_3 \cdot 6H_2O$, and $2CaO \cdot Al_2O_3 \cdot 3H_2O$. The first compound is identical with Thorvaldson's hydrate which was prepared by the direct hydration of $3CaO \cdot Al_2O_3$. At low temperatures and pressures the dicalcium aluminate hydrate with 6 or 7 molecules of water is formed. At higher temperatures and pressures the hydrate with 3 molecules of water is formed. The compounds were not obtained in the pure state. L.T.B.

Properties and use of sodium silicate. Manufacture of siliceous cements. E. LEMAIRE. *Génie civil*, **99** [20], 502–505 (1932); *Chim. & ind.*, **27** [4], 846–47 (1932).—Cements called "anti-acid" are not unattackable by acids but become so when in contact with them. They are mixed with sodium silicate which is the chief agent of hardening and of acid resistance. Under the action of mineral or organic acids (except hydrofluoric), sodium silicate precipitates orthosilicic acid which dehydrates and produces metasilicic acid. This colloid is soluble in potash and soda in ebullition and also in alkaline carbonates. Sodium silicate is decomposed by carbonic acid in the presence of water; carbonic acid neutralizes soda and silica gel is liberated. The adherence of sodium silicate to brick is strong. The cements are composed of inert matter (siliceous sand, slag), a mixture of inert material and an acid (silica incompletely dehydrated, certain pozzuolanas), or of a mixture of an inert matter with a neutral or alkaline material. In the latter cements alumina, slaked lime, magnesia, plaster, nitrate, chloride, or calcium acetate acts by forming insoluble silicates. M.V.K.

Reactions taking place between Portland cement and water. HANS KÜHL AND W. TAO. *Zement*, **21** [8], 105–11; [9], 120–26; [10], 134–39 (1932); *Chim. & ind.*, **28** [2], 349 (1932).—The hydration begins by an intensive hydrolysis of one of the constituents of cement. The analyses show that the aluminous compounds of Portland cement are extracted from cement grains by the liquid (limewater). They hydrate in a liquid phase and are precipitated in the form of hydro-aluminates. The silicates liberate their lime content (about half), hydrate on the surface of contact between the grains and the solution or in the interior of the grains, and produce a hydrosilicate poor in lime. The latter covers the cement grains with a coat of gel. The ferrites play only a secondary rôle. The hydration of different constituents varies in velocity. The decomposition of tricalcium silicate produces a supersaturation in lime of the reacting liquid. The dissolved lime can be found in a colloidal state or in a combined form. With regard to the solubility of hydro-silicates and hydro-aluminates, the former are only slightly soluble while the latter dissolve at the rate of 0.01 g. of alumina per liter of saturated limewater. Among the compounds resulting from the action of water on cement, some are transformed from the initial amorphous state into the crystalline state. The phenomenon of hardening of Portland cement seems to be of a colloidal nature. M.V.K.

Portland cement with a maximum lime content. HESS. *Zement*, **20** [40], 882–84; [41], 904–907 (1931); abstracted in *Chim. & ind.*, **27** [3], 601–602 (1932).—The formula, $3CaO \cdot SiO_2 + 3CaO \cdot Al_2O_3 + 2CaO \cdot Fe_2O_3$, approaches the best experimental data. A cement whose degree of lime saturation is equal to 100%, the maximum theoretical lime content calculated from the formula given, is easily produced. A lime content of more than 100% produces swelling of cement. M.V.K.

Recast analysis; its relation to the chemistry of Portland cement. III. Relation of actual compound composition to potential. LOUIS A. DAHL. *Rock Prod.*, **35** [16],

32–35 (1932).—Relations between components of raw materials used in the manufacture of Portland cement are studied, using graphical methods. For Part II see *Ceram. Abs.*, **11** [11], 596 (1932). W.W.M.

BOOK

Investigations on Calcium Aluminates and Their Compounds with Calcium Chloride and Calcium Sulphate. (Récherches sur les aluminates de calcium et sur leurs combinaisons avec le chlorure et le sulphate de calcium.) HENRY LAFUMA. Librairie Viubert, Paris, 1932. 16 F. Reviewed in *Chim. & ind.*, **27** [6], 1499–1500 (1932).—A study of conditions in which aluminates combine with calcium chloride and sulphate permitted the determination of the problems relating to the action of sulphate of lime on aluminous cements. The salt of Candlot, the chloro-aluminate of calcium (found by Poisson), and sulpho-silico-aluminate of lime are also discussed. M.V.K.

PATENT

Process of producing cement composition. H. K. MOORE (Brown Co.). U. S. 1,880,038, Sept. 27, 1932. A hydraulic cement composition resistant after setting to attack by water and whose analysis indicates a dominant mol-proportion of barium oxide base, a smaller mol-proportion of silica, and a still smaller mol-proportion of alumina, the mol-proportion of base in the composition being much lower than that of Portland cement.

Enamels

Manufacture of porcelain enamel frit for application to cast iron and sheet steel. I. H. D. MCLAREN. *Clay Prod. News*, **5** [6], 7–9 (1932).—McL. classifies enamel frit according to its application as "dry-process" and "wet-process" frit. Fritting reactions and the effects of various constituents on the enamel properties are given. Some sample enamel batches are listed with the characteristics required of a formula for a workable enamel. **II.** *Ibid.*, **5** [7], 6 (1932).—Enamel smelting furnaces are classed as rotary and reverberatory. Smelting operations and reactions are described. W.W.M.

Industrial method for controlling the consistency of an enamel suspension. D. S. LEV AND M. S. BOROZDINA. *Mineral. Suir'e*, **6** [5–6], 568–76 (1931); *Chim. & ind.*, **27** [3], 607 (1932).—The three values which especially characterize an enamel suspension are (1) mobility, (2) limit of elasticity, and (3) time between the beginning and end of the liquid state of the suspension on the surface of the object. The chief factor is the limit of elasticity. The authors discuss several methods for successfully controlling the enamel production. The first consists in determining the weight of the suspension which adhered to a surface of known dimensions. The second consists in measuring the duration of the mobile state of the enamel on an iron plate and determining the fineness of grinding of the enamel according to the method of Cook. By the utilization of these methods of control the consistency of enamels is improved and rendered satisfactory and a uniform coat is produced. M.V.K.

Simple analyses of raw materials used in the manufacture of enamel. IV. ANON. *Emailwaren-Ind.* [Émail], **9** [35], 41 (1932).—The general properties, analysis, and distinctive characteristics of sodium carbonate are described. For Part III see *Ceram. Abs.*, **11** [11], 552 (1932). M.V.K.

Application of bentonite clays in the enameling industry. D. S. LEV. *Mineral. Suir'e*, **6** [10–11], 1021–22 (1931).—The use of bentonite as a flotation agent in the American enameling industry and the possibility of using Russian bentonite clays for the same purpose are discussed. M.V.K.

Applying and firing ground coat dry-process enamels. ANON. *Better Enameling*, **3** [3], 10 (1932).—Equipment is listed and methods are given. Illustrated. W.W.M.

Applying and firing finish coat dry-process enamels. ANON. *Better Enameling*, **3** [4], 13–16 (1932). W.W.M.

Foundry cores and core binders. LAWRENCE E. BARRINGER. *Better Enameling*, **3** [2], 27–28 (1932).—B. outlines the properties required in the baked foundry core. It has been found that the alkyd resin type of synthetic resin possesses all of the qualifications necessary for a foundry core binder. W.W.M.

Method for drilling enameled castings. J. J. WARNER. *Better Enameling*, **3** [3], 32 (1932).—The object in drilling enameled castings is to get an ample supply of turpentine around the drill. This can be done by building a small reservoir around the spot to be drilled. W.W.M.

What the foundryman must know about enameling castings. J. WISSER. *Giesserei*, **18** [35], 686–88 (1931); abstracted in *Chim. & ind.*, **27** [2], 353 (1932).—Pieces to be enameled are first heated, subjected to a sandblast, and then immersed in or coated by a layer of ground enamel of a mixture of borax–sand–soda with kaolin and magnesia. They are fired to 900° in furnaces of different types heated by oil, gas, or pulverized coal, or electric furnaces. Special care should be taken to determine the properties of the casting and the presence of grease or sand grains on the surface or in cavities on the surface, all of which prevent the adherence of the enamel or produce blisters. A poor adherence of the enamel to the casting may also be produced by a defective furnace and defective qualities of the fuel. The coefficients of dilatation of the pieces vary widely. In cast-iron pieces having a high content of silicon, graphite separates on the surface and may cause blisters on the enamel. The separation of graphite tends to appear when the casting is overfired. The presence of sulphur in the metal in the form of iron or manganese sulphide produces spots similar to rust. M.V.K.

Automatic pickling machines. H. R. SMALLMAN. *Better Enameling*, **3** [6], 9 (1932).—Automatic pickling machines are described including the standard return type, straight-line full automatic machine, and the dwell-type automatic machine. Illustrated. W.W.M.

Pickling in enamel plants. HANS HADWIGER. *Glashütte*, **62** [32], 543–44 (1932).—Methods used for pickling raw ware and drying are described in detail. M.V.K.

Washing clay. ANON. *Better Enameling*, **3** [3], 17 (1932).—A method is described for removing foreign materials from the clay used in the mill. W.W.M.

Manufacture of marble enamel. ANON. *Glashütte*, **61** [37], 669–70 (1931); *Chim. & ind.*, **27** [2], 355 (1932).—The marble enamel can be produced by different methods. The objects are coated with the ground enamel which after firing is coated by a thin layer of colored enamel. Three or four different colored enamels can be mixed or the veins are obtained by sprinkling the ground enamel with solutions containing appropriate pigments (sulphates of Cu, Ni, Co) without clay, after which the wet layer is covered with sodium carbonate or dry potash. M.V.K.

Clays and color in porcelain enamel. G. H. MCINTYRE. *Enamelist*, **9** [7], 10 (1932).—McI. describes experiments using various clays in colored enamels and discusses their effects on deep blue, black, and white enamels. He shows that the use of the proper clay cuts the cost of the colored enamel and he presents a chart showing the fitness of a foreign clay and a domestic clay for use in enamel. W.W.M.

Color matching in the enamel plant. WILLIAM BALDWIN. *Enamelist*, **9** [5], 10 (1932).—B. describes and discusses color matching practice at the enameling plant of the American Radiator Co. W.W.M.

Uses of titanium white. B. HUBERT. *Chim. & ind.* [Special No.], pp. 679–82 (March, 1932).—H. discusses in detail the properties of titanium white as a pigment and describes some of its uses in the ceramic, textile, rubber, leather, etc., industries. M.V.K.

Checking the sag-resisting properties of enameling iron. HOMER BUTTS. *Better Enameling*, **3** [6], 21 (1932).—B. describes equipment and a method for testing sag resistance of enameling iron. Illustrated. W.W.M.

Investigation of enamel cleaners. FERRO ENAMEL CORP. *Enamelist*, **9** [6], 8–11 (1932).—Laboratory tests were made to determine the abrasive action, if any, of several commercial scouring powders. The results are shown by means of photographic plates. W.W.M.

Cleaning and preparing castings for dry-process enameling. ANON. *Better Enameling*, **3** [2], 14–17 (1932).—Equipment for cleaning castings is listed and the cleaning process is described with illustrations. W.W.M.

Sandblasting tests to be formulated. EDITORIAL. *Can. Mining Met. Bull.*, No. 243, p. 325 (1932).—The committee appointed by the Canadian Ceramic Society has set up subcommittees in connection with the formulation of a series of standard tests for Canadian sands for sandblasting. Canadian sands are now finding much favor among Canadian enamelers and foundrymen. G.M.H.

"Sandblasting" without sand. HENRY R. POWER. *Metal Cleaning & Finishing*, **4** [9], 515–16 (1932).—The nonsiliceous blasting materials that are being increasingly used for sanitary and humanitarian reasons are, other than steel grit, the so-called electric-furnace abrasives, silicon carbide and fused alumina, in both of which "free silica" is practically absent. A detailed description is given of these two types of abrasives employed in blasting operations, especially on iron and steel castings and metallic surfaces in preparation for vitreous enameling. Illustrated. E.J.V.

Equipment for cleaning metal. XXI. R. W. MITCHELL. *Metal Cleaning & Fin-*

ishing, **4** [9], 491–95 (1932).—The theory and methods employed in the electrolytic cleaning of metal products preparatory to the application of finishes are discussed. For Part XX see *Ceram. Abs.*, **11** [11], 555 (1932). E.J.V.

Fundamentals in solving some enameling troubles. ANON. *Ceram. Ind.*, **19** [4], 187 (1932).—Causes that might produce bare spots, blisters, and a thin cover coat are cited. Data on opacifiers are given, and the use of reclaimed enamel is advised. W.W.M.

Expansion of cast iron. J. HOLM. *Emailwaren-Ind.*, **9** [38], 291–92 (1932).—H. has measured the effect of variations in the individual constituent elements of cast iron on its coefficient of expansion, with reference to the coefficient of expansion of the enamels that are to be applied. Variations in C, Si, Mn, and S content show very little effect on the coefficient of expansion, while slight variations in P content will produce a deviation of ±10 from the average, 291. For bathtubs and similar ware on which dry-process enameling is employed, H. recommends an enamel with a coefficient of expansion at least 10 points lower than that of the cast iron, while for wet-process enameling of drinking fountains, etc., an enamel with a coefficient of expansion 50 to 60 points higher is necessary. W.W.B.

Care of plain composition rubber graining rolls. L. D. DAVIS. *Better Enameling*, **3** [4], 20 (1932). W.W.M.

Proper use of spraying equipment. ANON. *Ceram. Ind.*, **19** [4], 176 (1932).—Practical advice for enamelers regarding selection, installation, operation, and care of spraying equipment is given. W.W.M.

Electric enameling kilns. II. H. NATHUSIUS. *Emailwaren-Ind.*, **9** [35], 270; [36], 275–76 (1932).—The Hagan electric furnace is discussed. For Part I see *Ceram. Abs.*, **11** [11], 555 (1932). M.V.K.

Continuous furnace. R. F. BENZINGER. *Better Enameling*, **3** [4], 25–27 (1932).—B. describes a continuous enameling furnace which uses no hooks or overhead conveyers. W.W.M.

Mechanical handling aids for vitreous enameling. J. B. NEALEY. *Enamelist*, **9** [12], 30–36 (1932).—N. describes the mechanical handling equipment in the plant of the U. S. Stamping & Enameling Company, Moundsville, W. Va. Motor-driven loop conveyer systems are used, about which are grouped the equipment for application, drying, and firing. W.W.M.

Crating porcelain-enameled sanitary ware. ANON. *Better Enameling*, **3** [5], 11–13 (1932).—Factors involved and proper methods of crating enameled sanitary ware are given. Illustrated. W.W.M.

Modern service and shop operation. F. R. PORTER. *Enamelist*, **9** [8], 7 (1932).—P. describes the trend of the industry toward better service and depicts an ideal set-up for modern production in porcelain enamel shop operation. W.W.M.

Reëmploying waste enamel. ANON. *Emailwaren-Ind.* [Émail], **9** [35], 42–43 (1932).—Waste enamel constitutes a product of the same value as fresh enamel and therefore can be used again. There are two methods of using it, (1) to grind it again with some additions and proceed as usual, and (2) to re-fuse it and produce a new enamel. The former method does not permit the use of the enamel as it is, and, depending on its origin, the following admixture should be used: from 2 to 4% clay, 1 to 2% sodium carbonate or 1 to 2% borax, 2 to 5% ammonium carbonate or 2 to 5% of an opacifier for white enamels, or 1 to 2% of a coloring oxide for a colored enamel. Several compositions for different kinds of enamel are given. M.V.K.

Resin products as competitors to enameled ware. V. C. FAULKNER. *Foundry Trade Jour.*, **47**, 23 (1932).—The foundry industry is facing tremendous competition from resinoid plastics, particularly in transatlantic-liner fittings. F. suggests that aluminum alloys should be vitreous enameled (the problem is the low melting point of light alloys). Addition of Be (melting point 1200°C) would give the necessary margin of temperature if the cost of Be could come down. H.H.S.

Safety and health in the porcelain enameling industry. STEWART J. OWEN, JR. *Better Enameling*, **3** [5], 4 (1932).—Safety and health problems of the porcelain-enameling industry are cited. W.W.M.

Use of friezes in modern architecture. WM. HOGENSON. *Better Enameling*, **3** [9], 17 (1932).—Friezes are discussed at length and the use of enamel friezes in colors, in raised or embossed effects, or both are mentioned as a possibility. W.W.M.

Enamel construction. ANON. *Enamelist*, **9** [8], 11–13 (1932).—A series of drawings shows the details of construction patented by White Castle System of Eating Houses, Wichita, Kansas. The method was developed by Lloyd W. Ray. See also *Ceram. Abs.*, **11** [11], 554 (1932). W.W.M.

Development of porcelain enameling. ROBERT D. LANDRUM. *Ceram. Ind.*, **19** [4], 183 (1932).—L. gives the development of the porcelain enameling industry from a close-mouthed guild to its present status and the history of its products. W.W.M.

Art of vitreous or porcelain enameling. W. MAVOR. *Clay Prod. News*, **5** [5], 7–9 (1932).—M. gives facts concerning the history of the art of enameling which date back to the 8th or 7th Century B.C. He describes the development of cloisonné, the champlevé process, the use of translucent enamels in Italy, the Limoges school and its decline, and the rise of the miniature style which is still in vogue. The painting is done on an opaque white ground coat and after firing is covered by a transparent glass. M. touches on past and present uses of enamel. W.W.M.

History of the enamel industry. OTTO VOGEL. *Emailwaren-Ind.*, **9** [35], 267–69 (1932).—V. discusses the beginning of the enamel industry in England in the 18th and 19th Centuries. See also *Ceram. Abs.*, **11** [3], 161 (1932). M.V.K.

Enamel industry in China. TUNG WEI LIEN. *Enamelist*, **9** [8], 10 (1932). W.W.M.

BOOK

Impurities in Metals. Their Influence on Structure and Properties. C. J. SMITHELLS. *Trans. Faraday Soc.*, **28** [6], 559 (1932); see also *Ceram. Abs.*, **10** [3], 178 (1931). G.R.S.

PATENT

Process for the manufacture of opacifiers. LUDWIG WEISS. U. S. 1,881,303, Oct. 4, 1932.

Glass

Constitution of glass in the light of the solvation theory. W. WEYL AND W. EITEL. *Naturwissenschaften*, **20** [22–24], 422–25 (1932).—All the theories which have been advanced to explain the constitution of glass heretofore have not been completely successful in solving the problem. According to this theory glass is a solution of the single molecules of the constituents which are able to dissociate thermally and electrically. The atomic groups which result thereby exert electrical forces. The type of forces referred to are such as are discussed in the constitution of solutions, especially the forces referred to in the theory of solvates. The thermodynamical properties of glasses are discussed as they must be developed under such a theory of constitution. L.T.B.

Influence of temperature on glass from the point of view of its hydrolytic resistance. WALTER TEPOHL. *Glastech. Ber.*, **9** [7], 390–93 (1931); abstracted in *Chim. & ind.*, **27** [2], 348 (1932).—Investigations made on different glasses show that the attack of moist air does not correspond to the hydrolytic attack and that the latter attack on a window glass at 80 or 100° does not indicate the resistance of the glass to weathering. The method of Mylius (*Silikat-Z.*, **1**, No. 1–3), based on the exposure of glass to moist air, has defects but there are no other more exact methods for determining the natural efflorescence of glass. M.V.K.

Viscous-temperature relationship and some inferences on the nature of molten and of plastic glass. S. C. WATERTON. *Jour. Soc. Glass Tech.*, **16** [62], 244–53 (1932).—From actual viscosity measurements of English and Lillie on soda-lime-silica glasses the conclusion is drawn that at temperatures lower than that at which $\log_{10}\eta = 8$, the glasses are either nonassociated or the degree of association has become constant. At higher temperatures the curve obtained by plotting $\log_{10}\eta$ against the inverse of the absolute temperature departs from linearity and W. interprets this as being due to the process of dissociation setting in. In the case of the soda-boric oxide-silica glasses, it is concluded that the degree of association increases as the boric oxide content increases. No evidence was found of the existence of an "aggregation temperature" suggested by Fulcher. G.R.S.

Investigations on the tensile strength of glass. E. J. GOODING. *Jour. Soc. Glass Tech.*, **16** [62], 145–70 (1932); for abstract see *Ceram. Abs.*, **11** [6], 353 (1932). G.R.S.

Interpolation formulas for the refractive indices of glass. MRS. E. GIFFORD. *Trans. Opt. Soc.* [London], **32**, 69–72 (1930–31).—Formulas for the refractive indices of glasses for five lines are given using measurements for only *C*, *D*, and *F* lines. The variable, μ-1, instead of μ is used. Numerous examples are cited showing the application of the formulas and an estimate of the amount of error is indicated. J.T.L.

Acid stability of glass in dependence on the chemical composition and the efflorescence of glass. II. ALPONS WEBERBAUER. *Glastech. Ber.*, **10** [8], 426–35 (1932).—

The power of attack of acids on glass depends on their degree of dissociation, *i.e.*, acids dissociating strongly attack more powerfully than those dissociating weakly. The power of the acid attack increases with increasing concentration of the acid. The attackability in per cent of systematically varied glasses in the form of grits by a 10% HCl solution at 100° was investigated. The following conformities to law were found for the series of glasses investigated: (1) An increased alkali content impairs glasses. (2) Pure soda glasses show a better acid resistance than pure potash glasses. (3) When passing from soda to potash glasses, the acid stability changes approximately linearly. (4) Through the introduction of 2- and 3-valent oxides instead of silica, the glasses are improved in regard to acid attack until the optimum is reached; after that they deteriorate rapidly. The amount of improvement is greatest with the first per cent of oxides introduced. The sequence of the separate oxides in regard to their improving or impairing action varies with different percentages. (5) The position of the optimum moves from the glasses with the strongest bases toward those containing weaker bases. In alumina glasses the optimum of resistance occurs at about 15% Al_2O_3. A comparison of the hot acid attack with the attack of hot water shows that there is no relationship between them. This is proved by the fact that the hot water attack is recognized as an alkaline attack. On the other hand, through the determination of the cold water attack and cold acid attack a far-reaching relationship between these and the hot acid attack is established. There is also a relationship between the latter three kinds of attack and the conductivity of the hyaloid membrane; this relationship is slightly effaced, however, because the different oxides are valued by weight in chemical methods, while in the conductivity of the hyaloid membrane they are valued according to their special values of conductivity. The efflorescence of glasses must be regarded as a cold water or a weak acid attack but never as an alkaline attack. It is determined that no relationship exists between efflorescence and hot water attack. The relationship between efflorescence and cold water attack as well as between hot and cold acid attack is proved by researches on efflorescence on numerous glasses. Accordingly, a hot acid test can be regarded as a rapid test for efflorescence. For Part I see *Ceram. Abs.*, **11** [11], 560 (1932). M.V.K.

Some practical views on the fusion of glass compositions. M. BABILLE. *Céram. Verrerie*, No. 834, pp. 687–89 (1931).—B. discusses some of the more common difficulties encountered in glass fusion and the resulting defects. The causes of bubbles, streaks, and pebbles and the corresponding remedies are given. M.H.B.

Behavior of glass during working. M. BABILLE. *Céram. Verrerie*, No. 835, pp. 15–16 (1932).—B. discusses viscosity and the annealing range as primary factors in the behavior of glass during working, and gives temperature, constituents of glass, and the form in which these constituents are added as governing factors. M.H.B.

Influence of thermal treatment on opacity of fluoride opal glasses. I. I. KITAIGORODSKY AND S. M. KUROVSKAYA. *Jour. Soc. Glass Tech.*, **16** [62], 210–18 (1932).—Experiments are given on the effect of heat treatment in developing opacity in a glass of the percentage composition, SiO_2 67.52, Al_2O_3 3.81, CaO 5.86, Na_2O 18.54, F_2 4.00, and in two other glasses of similar composition varying in amounts of SiO_2, CaO, and Na_2O. Prepared slabs of the glasses were heated at 700° for periods varying from 1 min. up to 4 hr. and at temperatures from 450 to 900° for a constant period of 20 min. The general transmission, unscattered transmission, reflection, and absorption were measured for each specimen. The relation between heat treatment and optical properties of opal fluoride glasses is in accordance with Tammann's theory of crystallization from supercooled solutions and each glass has its own maximum opacifying temperature. For the glass studied it lies between 650 to 700°C. G.R.S.

Study of volatilization and vapor tension at high temperature of an alkali-lead oxide-silica glass. E. PRESTON AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **16** [62], 219–39 (1932).—A study was made of the volatilization which occurs when a glass of the composition, SiO_2, 55.57, PbO 29.83, Al_2O_3 ($+Fe_2O_3$) 1.29, CaO 0.22, Na_2O 5.18, K_2O 7.60, was heated in a controlled manner in an electric furnace at temperatures from 900 to 1400° for periods up to 200 hr. Lead oxide was the most volatile, alkaline oxide being appreciable only above 1200°. A straight-line graph was obtained on plotting log (rate of initial loss) against $\frac{1}{T^\circ\ (\text{abs.})}$, thus showing a relationship similar to that between vapor tension and temperature. The simple relationship, $\frac{x}{A-x} = kt$, where x was the amount volatilized at time, t, and A the original amount of the volatile constituent in the glass, held up to the time of half loss. The area exposed, the depth, and the rate of diffusion in the glass all influenced the rate of loss from the surface. A long-period experiment established the fact that a definite concentration gradient is set up in a crucible

deep relative to the diameter. The general approximate equation connecting rate of volatilization with time and depth of glass (h), *i.e.*, $\log\left(\frac{A-2x}{A}\right) = -\frac{2kt}{h}$, was deduced. Vapor-tension determinations of the molten glass were carried out in a specially designed apparatus at temperatures between 1100 and 1360°, the values ranging from 0.16 mm. Hg at the former to 3.90 mm. Hg at the latter. The relationship between vapor tension and temperature was the same as between rate of volatilization and temperature. See also *Ceram. Abs.*, **11** [7], 406 (1932). G.R.S.

Effect of gases on a commercial glass containing lead oxide. J. H. PARTRIDGE. *Jour. Soc. Glass Tech.*, **16** [62], 121–30 (1932); see also *Ceram. Abs.*, **11** [7], 407 (1932). G.R.S.

Study of glass colored by gold and of gold deposits obtained by cathodic pulverization. J. LEBESGUE. *Récherches et inventions*, **12** [204], 263–68 (1931); *Chim. & ind.*, **27** [3], 605 (1932).—Through the introduction of 0.001 gold chloride into the vitreous mass in fusion, a glass is obtained by slow cooling which is colored into red, pink, blue, or brown. L. studied currant red glasses which possessed an absorption band in green through the spectroscope by transmission. The study of the absorption showed that the band is asymmetric; the glass highly transparent for red is only slightly so for blue, violet, and ultra-violet beyond the band. The glass with gold is more refracting than ordinary glass although less than glasses described by Brewster, Beer, and Faraday. The gold must be present in it in ultra-microscopic particles. In the second part of the study, L. examined the structure of gold deposits obtained by cathodic pulverization. M.V.K.

Color of selenium ruby glasses. H. P. ROOKSBY. *Jour. Soc. Glass Tech.*, **16** [62], 171–81 (1932); *Chem. Trade Jour.*, **90** [2351], 570 (1932); *Pottery Gaz.*, **57** [661], 879 (1932).—X-ray examination of a number of selenium glasses is described. The coloration is caused by the precipitation of particles composed of a solid solution of cadmium sulphide and cadmium selenide. Differences in the relative amounts of the two compounds in solid solution produce colors ranging from deep ruby to orange. G.R.S.

Distribution of silver and sodium between glass and nitrate and bromide melts in equilibrium. A. GUENTHERSCHULZE AND O. MOHR. *Z. tech. Physik*, **13** [8], 356–58 (1932).—In nitrate melts silver migrates into the glass in exchange with sodium. It is possible to extract all silver from sodium nitrate melts with a small silver content by treating them with glass powder. In bromide melts the migration of silver into glass is practically stopped by small amounts of sodium bromide. With electrolysis, all sodium first migrates into the glass, and only after that does the silver start to migrate. W.M.C.

Emission of glasses of the composition $B_2O_3 + Na_2O_3$. H. BOELLING. *Physik. Z.*, **33** [16], 625–32 (1932).—The emission of ions during a certain interval will give a curve which first decreases and then remains constant. An explanation for this phenomenon is found by assuming a loosening up of the lattice and the disappearance of irregularities in the surface. Increasing the temperature increases the emission. An increase of sodium content produces an increase in the current. The highest temperature in the experiments was 230°C. W.M.C.

Notes on the manufacture of special glasses. VI. Colorless glasses. ANON. *Glass*, **9** [8], 332–37 (1932).—A discussion is given on a series of tests using metallic selenium, barium selenite, and sodium selenite in the production of colorless glasses. The volatility of selenium was independent of its state, elementary or combined. Additions of arsenic produce a neutral tint and tend to stabilize the color. Effects of (1) salt cake, (2) sodium nitrate, (3) increased alumina, (4) borax, (5) zinc oxide, and (6) antimony and phosphoric acid are discussed. **VII.** *Ibid.*, **9** [9], 380–85 (1932).—General notes are given on the subject of seed prevention. The problem is studied in closer detail at each successive stage of production as follows: (1) composition of the batch, and (2) condition of the raw materials and batch, (*a*) grading of the raw materials, (*b*) effect of moisture, (*c*) the mixing process, and (*d*) storage of batch. For Parts I to V see *Ceram. Abs.*, **11** [11], 561 (1932). G.R.S.

Developments in optical glass manufacture. W. M. HAMPTON AND W. N. WHEAT. *Nature*, **128**, 926–28 (1931); abstracted in *Bull. Kodak Research Lab.*, **28** [6], 300 (1932); see also *Ceram. Abs.*, **11** [6], 351 (1932). J.L.G.

Glasses for the transmission and absorption of ultra-violet light. J. GRANT. *Glass*, **9** [9], 391–92 (1932).—A classification is given of the more important uses of ultra-violet rays in various branches of science and industry. Glass filters fall into two classes: (1) glasses which transmit ultra-violet light, quartz and Wood's glass, and (2) glasses

which absorb ultra-violet rays, Crookes' glass. The influence of various oxides on these classes of glass is discussed. G.R.S.

Strength of materials as affected by discontinuities and surface conditions. F. C. LEA. *Jour. Soc. Glass Tech.*, **16** [62], 181–209 (1932). G.R.S.

Nature of the sand for glassmelting. ANON. *Glashütte*, **62** [36], 625–27 (1932).—The nature of sand for glassmelting includes the shape of the sand grains, the proportion of particles sifted through two or more sieves, and the chemical composition. The chemical analysis and the sieve analysis of the sand are of importance. Sand of a known nature can not be replaced by another sand even when differing slightly. The selection of sand depends on the melting requirements of the batch and the kind and nature of other constituents of the batch. Many defects of the glass during melting are due to a wrong selection. The nature of the sand treated before melting must be determined again after the treatment. M.V.K.

Heat transfer through industrial glass tubing. J. T. LITTLETON, JR., AND H. C. BATES. *Chem. Met. Eng.*, **39** [6], 315–18 (1932).—Tables show heat transfer (1) from steam to cold water in a tubular condenser having seven glass tubes, (2) from hot to cold water in a tubular heater, and (3) from hot to cold water in a cascade cooler counter flow. The results provide a basis for computing the surface requirements of apparatus when the amount of heat to be transferred is known. G.R.S.

Production and properties of safety glass and its intermediate layer. E. DIETEL. *Bull. Kodak Research Lab.*, **28** [6], 313 (1932); for abstract see *Ceram. Abs.*, **11** [7], 408 (1932). J.L.G.

Safety glass and its testing. FRITZ OHL. *Diamant*, **54** [11], 163–65 (1932).—It is pointed out that a comprehensive set of standard tests for safety glass is necessary. The most important properties to be considered are (1) clarity and resistivity to decomposition by light, (2) safety against splintering, (3) strength to resist impact, and (4) resistivity against atmospheric conditions. Clarity can be determined by a visual examination. Splintering is determined by dropping a steel ball on a sheet of the glass according to specified conditions and weighing the splinters. The impact strength is estimated by a modification of this procedure. Four methods for testing resistivity to atmospheric influences are exposure (1) in the open, (2) to the ultra-violet ray lamp, (3) to moisture (damp storage), and (4) to high temperatures. Methods for making these tests and for determining the resistance to attack by water are described. A few tests for determining the chemical nature of the intermediate organic binding sheet are also mentioned. Illustrated. E.J.V.

Safety glass with a nitrocellulose base. A. BRESSER. *Nitrocellulose*, **4**, 57–60 (1932); *Glastech. Ber.*, **10** [8], 445 (1932).—B. reviews the manufacture of safety glass with a nitrocellulose base on the basis of numerous German and foreign patents, most of which were found to be practically valueless. See also *Ceram. Abs.*, **11** [5], 300 (1932). M.V.K.

Waste glass in glass plants. G. OPPERMANN. *Glastech. Ber.*, **10** [8], 421–26 (1932).—O. discusses (1) the dependence of the self cost of waste glass on the manufacturing stage, (2) self cost of waste glass minus the value of waste glass, (3) valuation of waste glass, (4) diagrams for calculating waste glass, and (5) diagrams for the hollow, pressed, bottle, pane, and plate glass industries. M.V.K.

Glass furnace performance factors. W. THOMAS. *Glass*, **9** [8], 354–55 (1932).—A curve is given in which the melting area of a glass furnace in square feet for one ton of glass melted is plotted against the number of kilograms of glass melted per square meter. G.R.S.

Old and new cooling furnaces for hollow glass. K. METZGER. *Glastech. Ber.*, **10** [8], 411–20 (1932).—K. discusses (1) cooling in dependence on the composition of glass and its distribution, (2) disadvantages and advantages of old systems of cooling furnaces and suggestions for their improvement, (3) results of measurements and investigations, (4) construction of doors, (5) cooling furnaces of Preuss, Winzen, and O. Maetz, (6) cooling furnace of Amsler-Morton and Hartford-Fairmont, (7) consumption of heat, and (8) new data for a furnace builder. M.V.K.

Thermal considerations in the operation of glass furnaces. F. STANG. *Glashütte*, **62** [32], 541–42; [33], 568–69 (1932).—Thermal efficiency of glassmelting furnaces is discussed with special regard to the development of highly refractory materials, the amount of waste gas, heat transfer, and preheating of air. M.V.K.

Checking furnace operation graphically. ANON. *Amer. Glass Rev.*, **51** [49], 9–10 (1932).—To demonstrate what economies can be effected by operating on high ratings and to check the general efficiency of the furnace, charts and illustrated examples of

their use are offered. These charts have been compiled on authentic daily information covering a three-month period of operation. E.P.R.

Problems of glass polishing. HANS MARTENSEN. *Z. Ver. deut. Ing.*, **76** [31], 761–62 (1932).—Dry polishing of glass is discussed with a theoretical explanation of the mechanism of the process. L.T.B.

Using "steel gravel" in refining glass. WALTER GUTMANN. *Glastech. Ber.*, **10** [8], 436–38 (1932).—The little known "steel gravel" works practically without dust, while with the use of quartz sand, dust is unavoidable. The use of steel gravel which has been tested practically in glassworking shows technical advantages. Different kinds of blasting apparatus can be used with steel gravel. M.V.K.

Aging of glassware. ANON. *Chem. Trade Jour.*, **91** [2354], 17 (1932).—To test the effect of storage conditions, ware was stored in the open and subjected to all weather changes. Other samples were stored indoors in a warm, dry atmosphere. Tests were also made on bottles for thermal endurance, bursting pressure, and breaking impact. Tests were conducted after storage lasting from 1 to 120 days. It was found that no appreciable change in the strength of machine-made bottles occurred for at least 1 month after manufacture; little change, if any, occurred in the thermal endurance for 3 months after manufacture. M.V.K.

Manufacture of rolled plate. XXV. ERNST LUTZ. *Glass Ind.*, **13** [10], 162–67 (1932).—Patents dealing with the heating of glass between the tank outlet and the rolls are discussed. The several newer types of leers for plate glass are described in detail. Illustrated. For Part XXIV see *Ceram. Abs.*, **11** [11], 562 (1932). E.J.V.

Quartz for fire fighting. G. LOCKHART. *Sci. Amer.*, **88** [9], 166–67 (1932).—The bulbs for sprinkler heads are now made from transparent quartz. In comparison with the old solder type of strut, the advantages include high fusing point and the facts that quartz is not vulnerable to corrosion and that loading or dust coating will not affect the reliability of the quartz head. The manufacture of the quartz bulbs is described in detail. Illustrated. W.M.C.

Old English glasses. XXXIII. Stirrup glasses. F. BUCKLEY. *Glass*, **9** [8], 349–50 (1932).—Wine glasses without foot are known as "Stirrup" or "Coaching" glasses. Some were made in the shape of a boot. Eight illustrations are shown. **XXXIV. Cordial glasses.** *Ibid.*, **9** [9], 389–90 (1932).—Descriptions are given of glasses of small capacity for holding cordials or strong waters. One of the earliest of these is in the true Venetian style, being decorated on the surface with two rows of little icicles and being supported on four little feet. These glasses probably date from the early part of the 17th Century, and, if not imported from Venice, must have been made in England by Venetian glassmen. Four illustrations are given showing the wide variety of stems. For Parts XXII to XXXII see *Ceram. Abs.*, **11** [10], 523 (1932). G.R.S.

Glass in the home. ANON. *Nat. Glass Budget*, **48** [21], 15 (1932).—Through the intelligent use of different kinds of flat glass it is now possible to transform a commonplace home into one of distinctive individuality. E.P.R.

Sightseeing at Corning. EDITORIAL STAFF. *Chem. Met. Eng.*, **39** [6], 310–13 (1932).—Numerous manufacturing operations including the new bulb plant are described. G.R.S.

Summer School in Glass Technology. ANON. *Glass*, **9** [9], 386 (1932).—A summary is given of the Summer School in Glass Technology for two weeks in the Department of Glass Technology of Sheffield University. G.R.S.

Optical glass in Italy. P. GINORY-CONTI. *Chim. & ind.* [Special No.], 484–89 (March, 1932).—G. discusses the raw materials used and technical operation of the manufacture of optical glass. M.V.K.

BOOKS

Manufacture of Hollow Glassware. M. A. BESBORODOV AND M. F. SHUR. 120 pp. State Publishing House, Moscow, Leningrad, 1931. Reviewed in *Jour. Soc. Glass Tech.*, **16** [62], 289 (1932). G.R.S.

Glassmelting Furnaces. JULIUS LAMORT. *Glashütte*, **62** [32], 546–47 (1932); for review see *Ceram. Abs.*, **11** [11], 563 (1932). M.V.K.

Bulletin Review

Report of the Heat Technical Council of the German Glass Industry for 1931. H. MAURACH. Published by the Heat Technical Council of the German Glass Industry, Frankfurt (Main), 1932. 7 pp. The report deals with (1) the engineer and glass plants, (2) the problem of waste glass, (3) cooling furnaces in hollow-glass plants, (4) observations on a glassmelting tank, and (5) efficiency and technique.

M. V. KONDOIDY

PATENTS

Apparatus for handling glassware. E. H. LORENZ (Hartford-Empire Co.). U. S. 1,878,156, Sept. 20, 1932.

Glassworking furnace. HENRI GEORGE. U. S. 1,878,392, Sept. 20, 1932. In a glassworking furnace, a mass of molten tin with the glass floating above and means connected to a source of electrical energy and adapted for supplying it to the molten tin.

Glassware-forming apparatus and method. R. W. CANFIELD (Hartford-Empire Co.). U. S. 1,878,465, Sept. 20, 1932. H. W. INGLE (Hartford-Empire Co.). U. S. 1,878,521, Sept. 20, 1932. O. C. K. HUTCHINSON, J. E. MCLAUGHLIN, AND L. D. SOUBIER (Owens-Illinois Glass Co.). U. S. 1,879,684, Sept. 27, 1932. C. W. SCHWENZFEIER AND J. E. MCLAUGHLIN (Owens-Illinois Glass Co.). U. S. 1,879,712, Sept. 27, 1932.

Glassmaking machine. H. C. GANTER (Atlantic Bottle Co.). U. S. 1,878,485, Sept. 20, 1932.

Glass-feeder apparatus. K. E. PEILER AND W. T. BARKER, JR. (Hartford-Empire Co.). U. S. 1,878,536, Sept. 20, 1932.

Suction device for gathering molten glass. R. W. CANFIELD (Hartford-Empire Co.). U. S. 1,878,576, Sept. 20, 1932.

Electric glassmelting tank. H. W. MCINTOSH (Hartford-Empire Co.). U. S. 1,878,591, Sept. 20, 1932.

Automatic dip regulator for suction-gathering receptacles, etc. K. E. PEILER (Hartford-Empire Co.). U. S. 1,878,597, Sept. 20, 1932.

Glass-cutting mechanism. C. F. BURDETT AND WILLIAM OWEN (Pittsburgh Plate Glass Co.). U. S. 1,878,818, Sept. 20, 1932. AUGUST KADOW AND C. W. SCHWENZFEIER (Owens-Illinois Glass Co.). U. S. 1,879,690, Sept. 27, 1932. O. C. NATLIS (Libbey-Owens-Ford Glass Co.). U. S. 1,881,220, Oct. 4, 1932.

Glassblowing machine. RICHARD LA FRANCE (Owens-Illinois Glass Co.). U. S. 1,878,863, Sept. 20, 1932.

Apparatus for making composite glass. J. H. SHERTS (Duplate Corp.). U. S. 1,878,899, Sept. 20, 1932.

Apparatus and method for drawing glass. A. E. SPINASSE (Pittsburgh Plate Glass Co.). U. S. 1,878,906, Sept. 20, 1932.

Machine for making articles from molten material. F. H. LOBB (Hartford-Empire Co.). U. S. 1,878,942, Sept. 20, 1932.

Mechanically grinding concave lenses. F. W. GEHRKE (Agfa Ansco Corp.). U. S. 1,879,179, Sept. 27, 1932.

Apparatus for feeding glass charges. CLYDE NAGLE AND C. B. HOOPES (Hartford-Empire Co.). U. S. 1,879,420, Sept. 27, 1932.

Machine for forming hollow-glass articles. AUGUST KADOW AND R. G. ALLEN (Owens-Illinois Glass Co.). U. S. 1,879,689, Sept. 27, 1932.

Process and apparatus for tempering glass. BERNARD LONG (Soc. anon. des manufactures des glaces et produits chimiques de St.-Gobain, Chauny, et Cirey). U. S. 1,879,698 and 1,879,699, Sept. 27, 1932.

Mechanism for skimming and stirring glass. J. F. RULE (Owens-Illinois Glass Co.). U. S. 1,879,711, Sept. 27, 1932.

Glass furnace. L. D. SOUBIER (Owens-Illinois Glass Co.). U. S. 1,879,718, Sept. 27, 1932. JOSEPH HAULIK. U. S. 1,879,899, Sept. 27, 1932. In a glass-furnace hearth, a transverse hearth-bed surface on each side of the median line of the hearth, each surface being inclined downwardly toward the sides, a series of cupped cleaning stones in each hearth-bed surface in inclined surface alignment with the bed surfaces, and each cleaning stone having a focal point of débris discharge near the side edges of the hearth, and a plurality of longitudinal cooling and ventilating flues beneath and in proximity with the hearth-bed, each flue having a port in direct communication with atmospheric air and means for providing a draft near the flue ports for the purpose of frequent renewal of the cooling air within the ventilating flues.

Method and device for conveying glass plates, etc. LAMBERT VON REIS (American Bicheroux Co.). U. S. 1,879,720, Sept. 27, 1932.

Ophthalmic lens. A. E. GLANCY (American Optical Co.). U. S. 1,879,800, Sept. 27, 1932. E. D. TILLYER (American Optical Co.). U. S. 1,880,029, Sept. 27, 1932.

Mold for glassware-forming machines. V. E. HOFMANN (Owens-Illinois Glass Co.). U. S. 1,879,872, Sept. 27, 1932.

Sheet glass forming and annealing method and apparatus. JULIUS SYLVESTER (Simplex Engineering Co.). U. S. 1,879,998 Sept. 27, 1932.

Leer. W. A. MORTON AND E. W. PAXTON (Highland Western Glass Co.). U. S. 1,880,268, Oct. 4, 1932.

Apparatus for annealing glassware. H. A. WADMAN (Hartford-Empire Co.). U. S. 1,880,536, Oct. 4, 1932.

Electrode for glassmelting furnaces. H. A. WADMAN (Hartford-Empire Co.). U. S. 1,880,540, Oct. 4, 1932.

Process and apparatus for making glass. H. A. WADMAN (Hartford-Empire Co.). U. S. 1,880,541, Oct. 4, 1932.

Control system. H. A. WADMAN AND H. W. MCINTOSH (Hartford-Empire Co.). U. S. 1,880,542, Oct. 4, 1932.

Apparatus and process for making window sheet or flat glass. W. H. POWELL. U. S. 1,881,327, Oct. 4, 1932.

Method and apparatus for the production of glass threads. O. KRÖGER AND O. OSWALD. Brit. 379,274 and 379,275, Sept. 7, 1932.

Machine for fabricating laminated glass. W. C. BULL. Brit. 379,324, Sept. 7, 1932.

Rolling of composite glass sheets. PILKINGTON BROS., LTD., AND H. SMITH. Brit. 379,769, Sept. 14, 1932.

Apparatus for cutting flat glass. PILKINGTON BROS., LTD., AND F. E. SLOCOMBE. Brit. 380,135, Sept. 21, 1932.

Process and means for manufacturing waveless plate glass, etc. Y. BRANCART. Brit. 380,425, Sept. 21, 1932.

Heating apparatus for use in the manufacture of glass bottles. G. E. BATESON AND H. BATESON. Brit. 380,460, Sept. 28, 1932.

Method and apparatus for frosting glass articles. CORNING GLASS WORKS. Brit. 380,464, Sept. 28, 1932.

Double-focus spectacles, eyeglasses, etc. EREL SOC. ANON. Brit. 380,636 and 380,725, Sept. 28, 1932.

Glassmelting tanks. L. MELLERSH-JACKSON (Hartford-Empire Co.). Brit. 380,679, Sept. 28, 1932.

Structural Clay Products

Porosity in brick. V. I. *Rev. mat. constr. trav. pub.*, No. 275, pp. 151–52 *B* (1932).—Researches of Hans Hirsch on the porosity in brick produced by lignite and saw dust are discussed. See also *Ceram. Abs.*, **11** [4], 244 (1932). M.V.K.

Small brick houses. A. LEE. *Tonind.-Ztg.*, **56** [69], 860–65 (1932).—The costs of small brick houses are outlined. Several examples of building the brick walls with and without reinforcing them are given and details of construction are shown. Illustrated. W.M.C.

Economy of reinforced brick manhole or pit construction. CHARLES H. FORK. *Brick Clay Rec.*, **81** [3], 99 (1932); for abstract see *Ceram. Abs.*, **11** [11], 569 (1932). E.J.V.

Effect of prolonged storage on ground fireclay sewer-pipe body. J. O. EVERHART. *Brick Clay Rec.*, **81** [3], 91–92 (1932).—Tests made on fresh ground clay, clay stored 1 week, and clay stored 2 weeks indicated that the fresh ground clay and that stored 2 weeks had greater plasticity and higher drying shrinkage than that stored 1 week. Firing tests showed that the clay stored 1 week had a tendency to be stronger and that stored 2 weeks was weakened. The stored clays also developed a surface scum that was not present in the fresh ground clay. A reaction between the scum and the salt glaze was obtained in the stored clay samples. E.J.V.

Calculating the costs of drain-pipe manufacture. G. SCHULZ. *Tonind.-Ztg.*, **56** [63], 789–90 (1932). W.M.C.

Standardization of hard-fired brick. ANON. *Tonind.-Ztg.*, **56** [65], 812–13 (1932).—Tentative data are given for standardization of the size of brick and their porosity, strength, and mechanical abrasion. W.M.C.

Hard-fired brick for road construction. ANON. *Tonind.-Ztg.*, **56** [71], 887–88 (1932).—Recent progress of road construction in the U. S. is reviewed. W.M.C.

Reorganization of a brick plant during the depression. F. LIEBELT. *Tonind.-Ztg.*, **56** [61], 768–69 (1932). W.M.C.

Containers for shipping brick and ceramic products. F. RIEDIG. *Tonind.-Ztg.*, **56** [71], 889–91 (1932).—New types of containers are illustrated. W.M.C.

PATENTS

Process of making light-weight ceramic material. RICHARD ERICSON (U. S. Gypsum Co.). U. S. 18,606, Sept. 27, 1932 (reissue). A porous ceramic material comprises the fired product resulting from heat-treating a mixture of foam and argillaceous material.

Structural material. H. C. PEPPER, R. L. HARRISON, AND D. E. ROSS (Rostone, Inc.). U. S. 1,877,959, Sept. 20, 1932. The process of producing an artificial structural material consists in mixing an alkaline earth base, a finely ground mineral material containing hydrated aluminosilicic acid, a coarse aggregate, and water in optimum quantity to produce complete reaction and heating the mass while retaining its essential water content until it is transformed into the desired material.

Structural material. H. C. PEPPER AND P. W. JONES (Rostone, Inc.). U. S. 1,877,960, Sept. 20, 1932. The process of producing an artificial structural material consists in mixing an alkaline earth base, a finely ground mineral material containing hydrated aluminosilicic acid, fibrous material, and water in optimum quantity to produce complete reaction and heating the mass while retaining its essential water content until it is transformed into the desired material.

Bricklayer's leveling and plumbing device. G. CORNUELLE. U. S. 1,878,448, Sept. 20, 1932.

Wall structure. H. P. C. KEULS (Sealed Joint Construction Corp.). U. S. 1,879,311, Sept. 27, 1932. M. L. WEBSTER. U. S. 1,880,561, Oct. 4, 1932.

Apparatus for laying tile drains. GEORGE HENDERSON AND W. M. HENDERSON. U. S. 1,879,683, Sept. 27, 1932.

Brick crate. D. M. KUCHTA. U. S. 1,879,756, Sept. 27, 1932.

Brick construction. M. CHASEMORE. Brit. 380,265, Sept. 21, 1932.

Refractories

Electrical resistivity of specialized refractories. HAROLD E. WHITE. *Jour. Amer. Ceram. Soc.*, **15** [11], 598–610 (1932).

Relation of crushing strength of silica brick at various temperatures to other physical properties. SANDFORD S. COLE. *Jour. Amer. Ceram. Soc.*, **15** [11], 611–21 (1932).

Quantitative determination of quartz, cristobalite, and tridymite in silica brick. P. P. BUDNIKOFF AND N. KASSYAN. *Savodskaya Lab.*, No. 4, pp. 39–48 (1932); *Feuerfest*, **8** [8], 126 (1932).—The determination of the specific gravity of silica brick gives results usable for estimating their quality. M.V.K.

Manufacture of silica brick from waste quartz of the Gluchovetzki kaolin plant. A. LITVINENKO. *Mineral. Suir'e*, **6** [10–11], 1012–17 (1931).—Data on the properties and qualities of silica brick manufacture are given in tables. M.V.K.

Magnesite brick not affected by temperature changes. K. ENDELL. *Stahl & Eisen*, **52** [31], 759–63 (1932).—Thermal expansion of magnesite brick was determined up to 1500°C and strength against distortion up to 900°C. The brick were cooled down rapidly from 900°C by the use of compressed air. Most brick cracked after being quenched once or twice, whereas some brick withstood the quenching test thirty times without cracking. The distortion was mainly elastic and only two brick not sensitive to sudden temperature changes showed a plastic distortion at more than 600°C. The exactness of Norton's formula was confirmed since it was found that the quenching behavior of the brick is directly proportional to the coefficient of expansion and in inverse ratio to the distortion. It was found from microphotographs that the greatest distortion is caused by the appearance of cleavage planes. These planes are missing entirely in the ordinary brick affected by temperature changes. They begin to appear in the medium-sensitive brick and appear markedly in the brick nonsensitive to quenching. This behavior is explained by the presence of periclase in magnesite brick and by the ability of these crystals to form cleavage planes. W.M.C.

Spalling of brick. ANON. *Blast Fur. Steel Plant*, **20** [9], 736 (1932).—A number of structural characteristics and physical changes undergone by brick in service and the effect thereof on their resistance to spalling are briefly enumerated. E.J.V.

Introduction of secondary kaolin in the firebrick mix for the purpose of increasing the alumina content and the refractoriness. P. P. BUDNIKOFF AND B. I. ENDOVITZKY. *Ber. deut. keram. Ges.*, **13** [6], 253–56 (1932).—Details are given of some experiments on the addition of a secondary kaolin to a refractory mix in order to improve its refractoriness and other properties. E.J.V.

Synthesis of spinels. K. S. NIKOGOSSIAN. *Mineral. Suir'e*, **6** [7], 728–31 (1931); *Chim. & ind.*, **27** [4], 851 (1932).—The natural minerals, nepheline and magnesite, were utilized for the production of spinels. A mixture of these two minerals was fused in an electric furnace at 1500° for 2 hr.; the products were maintained for 4 to 6 hr. at 1000°, and then gradually cooled. The products obtained and observed under a microscope showed that the results varied according to the proportion of nepheline and magnesite. With a proportion of 6% nepheline to 1% magnesite, the material obtained had the appearance of glass. When diminishing the quantity of nepheline, formations of typical crystals of spinels and longitudinal crystals of double refraction (forsterite) were observed in the vitreous mass. The maximum quantity of spinel (32%) was obtained with the proportion of 3% nepheline and 1% magnesite. The crystals were undeveloped, however, and difficult to isolate. With a proportion of 4:1, the quantity of spinels diminished (26 to 27%), but the crystals were separated and well formed. This proportion must be considered as the best. To isolate the spinels obtained, the fused mixture is crushed and treated with a dilute hydrochloric solution for about 12 hr. The insoluble spinel and silica is left. Decanting and washing of the residue permit the separation of the spinels easily. M.V.K.

Lattice constants of some compounds of the spinel type. HEINRICH HAUPTMANN AND JIRI NOVAK. *Z. physik. Chem.*, **B15** [4–5], 365–72 (1932).—The methods of preparing the compounds, Ga_2MgO_4, Al_2MgO_4, and Al_2ZnO_4, are given. X-ray diffraction patterns were obtained and the lattice constants and density of the compounds were determined. L.T.B.

Mechanical production of blocks used for the manufacture of melting pots. G. OEHLER. *Glastech. Ber.*, **9** [7], 393–96 (1931); abstracted in *Chim. & ind.*, **27** [2], 347–48 (1932).—O. discusses (1) the manufacture of blocks by hand and mechanically (pressing and milling), (2) pots produced mechanically and their defects, and (3) future possibilities of mechanized production (pressing and centrifugal machines). M.V.K.

Clay mixtures for glassmelting pots. IV. Corrosion-resisting properties. J. H. PARTRIDGE, G. F. ADAMS, AND J. R. LAIT. *Jour. Soc. Glass Tech.*, **16** [62], 131–44 (1932); for abstract see *Ceram. Abs.*, **11** [6], 370 (1932). G.R.S.

Modern types of refractories. F. H. NORTON. *Refrac. Jour.*, **8** [9], 360 (1932); for abstract see *Ceram. Abs.*, **11** [7], 415 (1932). E.P.R.

Study of different refractories. ANON. *Chim. & ind.*, **27** [2], 485 (1932).—It was found that carbon monoxide is capable of disintegrating some refractory clays at temperatures about 500°. M.V.K.

Investigation on refractory materials. IV and V. Properties of Mullex. MINORU NAKAMOTO AND KOZO KAWAI. *Jour. Soc. Chem. Ind.* [Japan], **34** [12], 470–71*B* (1931); abstracted in *Refrac. Jour.*, **8** [5], 200 (1932).—Mullex refractories consist chiefly of 80% mullite and 20% alumina. Tabulated data are given on specific gravity, porosity, apparent specific gravity, softening temperature (both with and without load), and strength under compression. M.V.K.

Contribution to the study of refractory oxides. F. GAMBEY AND G. CHAUDRON *Chim. & ind.* [Special No.], pp. 397–400 (March, 1932).—The authors studied the mechanical properties of MgO, $MgO{\cdot}Al_2O_3$, $MgO{\cdot}Cr_2O_3$, and $MgO{\cdot}ZrO_2$ at high temperatures. Testing at high temperatures has been made possible through the improvement of the optical measurements of the temperature by means of the black body of Rousseau and by modifying the heating element making possible measurements of long duration. A series of dilatometric curves is given and discussed. It was found that magnesia is viscous at 1400°, while spinel, alumina, and the compound, $MgO{\cdot}Al_2O_3$, are still hard. At 1700°, the mixture, $Mg{\cdot}ZrO_2$, pure zircon, and pure alumina are absolutely hard. The compound, $Mg{\cdot}ZrO_2$, is especially interesting since it is rigid even at 1900°. The viscosity of a pure oxide or a mixture can not be forecast from its fusing point. The deformation of magnesia at 1600° was detected by this method. See also *Ceram. Abs.*, **10** [10], 705 (1931). M.V.K.

Refractory materials for air-heating furnaces. ALFRED B. SEARLE. *Metallurgia*, **6** [34], 133–34 (1932).—The only refractory materials with a relatively high heat conductivity are the carbides, the best known of which is silicon carbide (SiC). The fire brick, hollow blocks, or pipes used in air-heating furnaces of the recuperator type are usually made of fire clay to which a variable proportion of grog has been added. Their conductivity is much less than that of silicon carbide or other carbides of metals, but if the walls are not too thick, good results are obtained. The brick or pipes should have ample resistance to the corrosive action of gases and flue dust; this is obtained with a large proportion of alumina and a close texture. The alumina should be in the form of mullite and not in the free state. The dust carried through the regenerator is of a basic

nature, readily combines with the silica or fire clay, and is particularly active in destroying porous brick. The dust, sometimes rich in metallic oxides from the furnace, is particularly corrosive. When the amount of dust is small, silica brick may be used though their sensitiveness to sudden changes in temperature is objectionable. Silica brick do not decompose carbon monoxide in the heating gases, and regenerators built of such brick do not choke rapidly. A classification of the requirements of the various parts of a recuperator or regenerator and the use of brick of a nature specially suited to each part are given. M.V.K.

Refractories for industrial furnaces. III. Selection of refractories. F. H. NORTON. *Fuels & Fur.*, **10** [8], 521–28 (1932).—N. discusses the selection of refractories for particular conditions such as constant temperature (never falling low enough to cause serious spalling) and variable temperature (having more or less rapid temperature changes in the spalling range) applications, as well as the testing of them for special purposes. A table is presented in which various furnace conditions and the best type of refractory to meet them are summarized. For Part II see *Ceram. Abs.*, **11** [10], 530 (1932). E.J.V.

Standard specifications of refractories for kilns and hearths. ANON. *Tonind.-Ztg.*, **56** [72], 903–904 (1932).—Provisional standard specifications are given covering the sizes and properties of the brick to be used as well as the dimensions of the hearths. W.M.C.

Observations on the behavior of refractory materials in continuous vertical retorts. A. T. GREEN. *Refrac. Jour.*, **8** [9], 323–33 (1932); for abstract see *Ceram. Abs.*, **10** [3], 197 (1931). E.P.R.

Manufacture and use of refractories in some European factories. R. M. KING. *Refrac. Jour.*, **8** [9], 340 (1932); for abstract see *Ceram. Abs.*, **10** [8], 574 (1931). E.P.R.

Bagasse fuel and boiler refractories. F. W. FREISE. *Refrac. Jour.*, **8** [9], 360 (1932); see also *Ceram. Abs.*, **11** [9], 494 (1932). E.P.R.

Protecting refractory brick. PAUL MUELLER. *Emailwaren-Ind.*, **9** [38], 292–96 (1932).—Ordinary fire brick are given a special 5-mm. refractory coating at the time of manufacture on those faces which are to be exposed. Their economy and other advantages over earlier methods and over special refractory brick are pointed out. W.W.B.

Types, uses, and testing of refractory cements. W. R. KERR. *Chem. Met. Eng.*, **39** [6], 331–32 (1932).—Clay and grog cements may be modified by the addition of a cold bonding agent such as sodium silicate, dextrine, or molasses. High-temperature bonds are discussed, and the uses and testing of cements are outlined. G.R.S.

Blast-furnace linings. W. J. REES. *Blast Fur. Steel Plant*, **20** [9], 736 (1932); for abstract see *Ceram. Abs.*, **11** [9], 494 (1932). E.J.V.

Stein suspended furnace roof. STEIN & ATKINSON. *Iron & Coal Trades Rev.*, **125** [3367], 376 (1932).—Refractory tile and a method of supporting them in a flat suspended arch designed primarily to fulfill the requirements of metallurgical furnaces are described. Illustrated. W.E.R.

Suspended combustion-chamber walls. ANON. *Mech. World*, **92** [2384], 241 (1932).—The ordinary solid wall soon becomes hot and allows molten slag to adhere. Repairs can often be carried out only by taking down the whole wall since the lower parts, which are usually affected, carry the whole weight. The suspended wall described consists of blocks separately attached to steel framing, the whole being air-cooled. E.P.R.

Iron compounds of bauxite. J. GYÖRKI. *Tonind.-Ztg.*, **56** [73], 913–14 (1932); for abstract see *Ceram. Abs.*, **11** [11], 574 (1932). W.M.C.

Technological study of the dead burning of dolomites. S. V. POTAPENKO. *Mineral. Suir'e*, **6** [5–6], 601–26 (1931); *Chim. & ind.*, **27** [3], 576 (1932).—Laboratory studies of the dead burning of dolomite having different contents of fluxes and fired for 3 hr. in a vertical electric furnace showed that dead burning is only obtained at the fritting temperature of the dolomite. This is a function of the dolomite content in fluxes, *i.e.*, silica, alumina, iron, and manganese, and decreases when the proportion of the latter increases. The presence of 1 to 6% silica in the raw dolomite increases the stability of the calcined material; 6 to 10% produces a certain degree of pulverulence on cooling of the calcined dolomite due to the formation of dicalcium silicate; with more than 10% silica the calcined mineral falls completely into powder. In regard to the lowering of the fritting temperature, manganese is first, followed by alumina, iron, and silica. A too high iron oxide content, however, lowers the stability of the fired dolomite as well as too low a ratio of magnesia to lime. The stability of dead-burned dolomite increases

with the time of calcination. The refractory properties of dolomite vary inversely with the content in fluxes. They are sufficiently refractory with 12% of fluxes. Application of these results in plants led to the following conclusions: (1) Dolomite absorbs large quantities of ashes and sulphur from the fuel during firing. These ashes increase the proportion of silica, alumina, and iron oxide in the fired product, thereby diminishing its strength; this can be prevented by firing with fuel oil. (2) Rotary furnaces permit treatment of all kinds of dolomites irrespective of their ease of fritting. The linings wear more rapidly, however, and the heat losses are greater. When the iron oxide content is less than 0.8%, hard unfired lumps are formed which are difficult to remove. The dolomite to be treated should contain at least 1.5% alumina + iron oxide + manganese oxide and 1% silica, but the proportion of the latter should not be too high. M.V.K.

Structure of sillimanite and related materials. W. H. TAYLOR. *Jour. Soc. Glass Tech.*, **16** [62], 111–20 (1932); for abstract see *Ceram. Abs.*, **11** [6], 370 (1932). G.R.S.

Souring of dead-burned magnesite. J. H. CHESTERS AND W. WEYL. *Trans. Ceram. Soc.* [Eng.], **31** [8], 295–316 (1932).—A magnesite brick batch is usually allowed to stand a few days before being made up into brick. The reaction which occurs during this "souring" period and during drying has been studied in the laboratory. The results of this test together with the results of plant practice suggest that the cracking of the brick in the drier is associated with excessive hydration produced by too wet a batch, excess of fine-grain material, or too high a temperature in the drier. A method has been developed whereby the amount of free and combined water and the amount of CO_2 in a sample of soured magnesite can be determined by heating *in vacuo* and measuring the gas evolution. The shape of the decomposition curve (temperature–gas evolution) shows the way in which the water and CO_2 are combined. Experiments with dead-burned magnesite show that the hydration velocity during the first day is much greater than that during subsequent days, apparently due to the hydration of very fine grains. Hydration velocity increases rapidly with decreasing grain size. The main reaction is to magnesium hydrate and, in the presence of air, a partial conversion to the basic carbonate. In the laboratory tests the soured magnesite was found to decompose over the temperature range of 300 to 400 °C. The hydration velocity is found to be sensitive to temperature variations, being eleven times as fast at 60 °C as at 18 °C. Where tunnel driers are used, periodic sampling should be made to insure that brick do not arrive in the hot zone while still containing appreciable amounts of free water. C.G.H.

Magnesidon in the electrical-steel industry. E. VON MALTITZ. *Blast Fur. Steel Plant*, **19** [6], 886 (1931).—Magnesidon with 95 to 98% magnesia and maximum 2% iron contains only small amounts of harmful fluxing admixtures. No bonding addition is used, but the small amount of iron acts as an efficient binder at the high temperature (3500 °F) at which the brick are fired. The softening point of magnesidon is high (over 3300 °F) and since the softening and not the melting point decides the life of a refractory (because chemical and mechanical action increases as soon as the brick has reached and passed its softening temperature), magnesidon is more resistant to chemical and mechanical attack at high temperatures than most refractory materials. Magnesidon brick are highly inert to spalling. These properties make magnesidon an ideal lining for the walls and roofs of basic electric furnaces. E.J.V.

Graphite in the French colonial empire. CH. BERTHELOT. *Chim. & ind.*, **28** [1], 229–35 (1932).—Graphite deposits found in the French colonies and the present situation of graphite mining in the world are described. M.V.K.

Preparation and shaping of refractory materials in Germany. III. OTTO PHILIPP *Feuerfest*, **8** [8], 115–19 (1932).—P. describes different types of mixers, presses, etc., used for working and shaping refractory mixes. For Part II see *Ceram. Abs.*, **11** [11], 576 (1932). M.V.K.

Development of the magnesite industry for the years 1931 to 1938. YA. L. GOL'SHTEIN. *Mineral. Suir'e*, **6** [7], 713–20 (1931).—G. discusses the manufacturing aspects of the projected increase of calcined magnesite from 48,600 T. in 1929 to 640,000 T. in 1938 and magnesite brick from 27,500 T. in 1929 to 600,000 T. in 1938. M.V.K.

Ramet. L. ANASTASIADIS. *Z. Metallkunde*, **24** [3], 66 (1932).—Tantalum carbide has been developed as a cutting material and is sold under the trade name "Ramet." L.T.B.

Faults in manufacturing refractories. H. KREMSKI. *Tonind.-Ztg.*, **56** [65], 814–15 (1932).—Different faults encountered in pressing refractory brick and means of avoiding them are discussed. Illustrated. W.M.C.

BOOKLET

P. B. Sillimanite. Edited by the European Koppers P. B. Sillimanite, Essen, 1931. 47 pp. Reviewed in *Feuerfest*, **8** [8], 125 (1932).—The booklet discusses in detail the raw materials (Indian cyanite), methods of working, and products manufactured by this company. See also *Ceram. Abs.*, **11** [4], 250 (1932). M.V.K.

PATENTS

Furnace bridge wall and cooling means therefor. C. H. JOHNSON (Babcock & Wilcox Co.). U. S. 1,878,524, Sept. 20, 1932.

Composite refractory articles. G. S. FULCHER (Corning Glass Works). U. S. 1,878,839, Sept. 20, 1932. The method of making composite refractory articles for use in contact with molten glass includes supporting a preformed refractory backing member in the upper part of a suitable mold so as to serve at least in part as the top slab thereof, pouring molten refractory material into the mold to fill completely the space unoccupied by the backing member, and annealing the completed article.

Making a refractory cast article. C. S. LINDER (Pittsburgh Plate Glass Co.). U. S. 1,878,870, Sept. 20, 1932. The process of making a refractory cast mullite into lump form, partially filling a mold with the crushed mullite, heating the mold and its content, and then flowing fused mullite into the mold to fill the mold, so that the fused mullite surrounds the pieces of crushed mullite.

Refractory body. J. S. HOGUE. U. S. 1,879,246, Sept. 27, 1932. An abrasion-resistant body comprising a cast-iron shell and refractory material disposed therein.

Refractory article. G. S. FULCHER (Corning Glass Works). U. S. 1,879,676, Sept. 27, 1932. An annealed cast refractory article for use in contact with molten glass, being provided with a reinforcing core of refractory material having the same composition as the article.

Refractory article. F. J. TONE (Carborundum Co.). U. S. 1,881,104, Oct. 4, 1932. A crucible formed from a refractory mix contains flaky particles which are oriented in the side walls of the crucible in a direction generally normal to the vertical axis of the crucible, whereby the side walls have a greater thermal conductivity in a horizontal direction than in a vertical direction.

Furnace-arch construction. P. L. A. MOREAU (M. H. Detrick Co.). U. S. 1,879,406, Sept. 27, 1932.

Composition for smelting hearths. CYRANO TAMA (Ajax Electrothermic Corp.). U. S. 1,879,589, Sept. 27, 1932. A refractory lining for induction furnaces contains from 20 to 98% beryllium oxide and another refractory material.

Checkerbrick and checkerwork construction. A. J. BOYNTON (H. A. Brassert & Co.). U. S. 1,880,011, Sept. 27, 1932.

Melting furnace. H. A. BRASSERT (H. A. Brassert & Co.). U. S. 1,880,012, Sept. 27, 1932.

Porous refractory articles. IVAR SETTERBERG. U. S. 1,880,157, Sept. 27, 1932. The process of making porous refractory articles comprises producing an intimate plastic mixture of nonsetting refractory material, gas-developing material, and water, allowing gas development to take place in the plastic mixture while in the cold state to produce a substantially uniform distribution of voids throughout the mass thereof, molding bodies of the porous plastic mass, impregnating the surface layer of the bodies with a binding agent while leaving the cores of the bodies free from binding agent, drying the impregnated bodies, and finally firing them at a high temperature.

Plugging means for crucibles, etc. D. C. DICKSON. U. S. 1,880,242, Oct. 4, 1932. Means for closing the discharge opening of a container of molten metal comprises a body of caked alumino-thermic mixture fashioned to close the opening.

Production of fritted magnesia containing iron. FRITZ CROTOGINO (Kali-Chemie Akt.-Ges.). U. S. 1,880,315, Oct. 4, 1932. A process for the production of fritted magnesia containing iron comprises heating calcined dolomite with sufficient ammonium chloride solution to convert almost the whole of its calcium oxide into calcium chloride, adding iron compounds that are insoluble in water, separating the undissolved magnesium oxide from the solution containing the calcium chloride, and sintering the magnesium oxide thus separated with iron.

Treatment of chamotte for glassmelting crucibles, furnace linings, etc. O. KRÖGER AND O. OSWALD. Brit. 380,290, Sept. 21, 1932.

Molding for the manufacture of refractory masses. E. LUX, W. H. DANIELS, AND E. KUHN. Brit. 380,432 and 380,433, Sept. 28, 1932.

Molding of plastic masses. E. LUX, W. H. DANIELS, AND E. KUHN. Brit. 380,434, Sept. 28, 1932.

Method for manufacturing refractory materials by melting slag rich in aluminum oxide and magnesium oxide in electric furnaces. TURE ROBERT HAGLUND. Ger. 550,419, May 6, 1927; *Feuerfest*, **8** [8], 124 (1932).—The refractories obtained have a high refractoriness and stability and a great resistance to sudden changes of temperature and chemical attack. They are suitable for use in Martin furnaces, crowns, coatings of furnace channels, and as material for furnace bases. M.V.K.

Terra Cotta

Some special types of crazing. H. G. SCHURECHT AND G. R. POLE. *Jour. Amer. Ceram. Soc.*, **15** [11], 632–37 (1932).

Effect of boric acid in raw milled glazes. KARL M. KAUTZ. *Jour. Amer. Ceram. Soc.*, **15** [11], 638–43 (1932).

Moler brick. ANON. *Danish Foreign Office Jour. Commercial Rev.* [in English], No. 136, pp. 67–70 (May, 1932).—The industrial evolution of the Danish diatomaceous earth called Moler is described. See also *Ceram. Abs.*, **10** [5], 382 (1931). H.H.S.

Meeting of the German Association of Roofing Tile Manufacturers. ANON. *Tonind.-Ztg.*, **56** [61], 766–68 (1932). W.M.C.

New standard specifications for stoneware. DECHEMA. *Tonind.-Ztg.*, **56** [59], 744 (1932).—Provisional standard specifications are given for flanges and flange connections of stoneware pipes. W.M.C.

Future of glazed brick. MAURICE BARRETT. *Brit. Clayworker*, **41** [485], 189 (1932).—It is necessary to recognize that glazed brick, as such, have had their day because of the many cheaper and, in some respects, more suitable substitutes. In early history glazed brick were used primarily as a decorative constructional material and many excellent results were obtained, some of which remain to this day. It is suggested that an effort be made to develop such brick and tile as a decorative medium and only in this direction is there likely to be any future for such products. The type of brick which should be produced is one which should be good and sound, but mechanical perfection should not be aimed at; rather, one should try to humanize it. It should be thin, preferably 2 inches thick, a full glaze should be avoided, and a dull surface of textural interest aimed for. Natural variation in color and slight inaccuracies of form should be deliberately exploited. Mottled granite, speckled, and polychrome effects have never been exploited, and should offer interesting possibilities for both exterior and interior use. R.A.H.

Ceramics and chemistry. PERCY C. KINGSBURY. *Jour. Chem. Ed.*, **9** [5], 795–819 (1932).—K. gives the history of modern industrial ceramic ware development from prehistoric to the present time. The ceramic industry has been transformed by modern equipment into one of the most important industries and the trial-and-error methods have been replaced by scientific research directed toward a specific end. The foundation on which this development work is built is given in detail and the steady improvement in ceramic ware for industrial purposes is demonstrated by a comparison of the physical and chemical characteristics of the product of today with those of a few years ago. Examples of modern apparatus and equipment made of ceramic ware and their application to the chemical and allied industries are illustrated and described. See also *Ceram. Abs.*, **11** [11], 579 (1932). A.K.

PATENTS

Hollow block structure. P. C. OLSEN (Federal Seaboard Terra Cotta Corp.). U. S. 1,877,953, Sept. 20, 1932.

Brick, tile, etc. R. ROUX, P. GUERY, AND P. WEYRES. Brit. 380,369, Sept. 21, 1932.

White Wares

Effect of preparation and calcination treatment on the properties of the kaolin-alumina mixtures, Al_2O_3-SiO_2. FRANK H. RIDDLE. *Jour. Amer. Ceram. Soc.*, **15** [11], 583–97 (1932).

Effect of talc additions on the firing behavior and some technically important properties of pure kaolin. R. RIEKE AND H. THURNAUER. *Ber. deut. keram. Ges.*, **13** [6], 245–53 (1932).—As a result of an investigation of mixtures of washed Zettlitz kaolin

with Göpfergrün talc the following observations were made: (1) With increasing talc content the P.C.E. drops to a minimum of cone 9 (about 1280°C) with 70% talc content, then rises again to the P.C.E. of pure talc, which is cone 18 (about 1500°C). (2) The sintering temperature is reduced by talc additions; the slope of the composition is analogous to that found for the P.C.E. (3) Sintering and fusion temperatures become gradually nearer with increasing talc content, until at 50 to 70% talc content they are identical. The composition of these mixtures lies in the neighborhood of the lowest melting eutectics in the system, MgO–Al_2O_3–SiO_2. (4) While the temperature interval of the greatest shrinkage increase in pure kaolin and high kaolin bodies lies between 1100 and 1200°C, it is displaced to a higher temperature (1200 to 1300°C) with increasing talc content. (5) With increasing talc content the specific gravity of the lower-fired body is increased; at higher firings it decreases up to 40% talc content and then increases with further increase in talc content. While the sintered body containing 20 to 50% talc has a specific gravity of 2.5 to 2.6, the value for the 70 to 90% talc body fired to sintering, as well as for pure talc, lies between 2.8 and 2.9. (6) All the mixes of kaolin and talc contain more or less cristobalite after firing to 1200°C. At higher firing temperatures the cristobalite content decreases in the low talc bodies, but in the high talc bodies it increases sharply. (7) The thermal expansion of kaolin is reduced by talc additions up to 30%, and then is greatly increased by further additions of talc. A raising of the firing temperature reduces the expansion to a considerable extent in every case. (8) In the high-fired bodies with 40% and more talc, clinoenstatite in large crystals can be detected; between 20 and 40% talc content another crystal form, probably cordierite, appears. E.J.V.

Effect of feldspar, marble, and magnesite, as well as firing temperature on the thermal expansion, elasticity, and torsional stability of whiteware bodies and the strains set up between the body and the glaze. R. RIEKE AND WALTER SCHADE. *Ber. deut. keram. Ges.*, **13** [8], 329–56 (1932).—Tests to determine the effect of the different firing temperatures and the addition of feldspar, whiting, and magnesite on several properties of whiteware bodies are described in detail. Results obtained show some interesting points. The high strength so greatly desired in white ware can be more readily attained by the addition of magnesite or feldspar than by the addition of lime. A high elasticity together with great strength is not possible as a high porosity is assumed for the first as compared with a thorough vitrification for the latter. As most whiteware glazes have a high thermal-expansion coefficient it is advantageous to produce ware with a high thermal expansion. This is attained either by the addition of magnesite, although the firing temperature can not be higher than 1200°C, or with a feldspar-containing body fired above 1200°C to produce a great amount of cristobalite more easily. A specially high expansion value is also obtained in a body consisting of clay and quartz only. In regard to a high torsional strength a firing temperature of 1150 to 1200°C is favorable, especially with bodies which contain feldspar and magnesite at the same time. For estimation of the fit of glaze and body the Harkort test is often used. According to W. Steger a deeper insight into the behavior of the glaze toward the body is furnished by the measurement of tension. The methods used with porcelain to measure the separate thermal expansions of body and glaze can not be used with white ware as they are apt to lead to false results. E.J.V.

Castability of lower Silesian kaolins and clays. ERNST SCHÖLZEL. *Ber. deut. keram. Ges.*, **13** [7], 322–27 (1932).—After determining the common ceramic properties of a group of kaolins and clays found in Bunzlau some experiments were conducted to determine the casting properties of these clays. Tests showed that the production of casting bodies out of Bunzlau clays was facilitated by the use of both humus-containing clays and kaolins, and that the kaolins are to be found among domestic raw materials. E.J.V.

"Moisture expansion" of ceramic white ware. R. F. GELLER AND A. S. CREAMER. Bur. Stand. *Jour. Research*, **9** [3], 291–307 (1932); R.P. 472.—This report supplements the reports of a number of investigations of "moisture expansion." The relative susceptibility of various materials, individually and as constituents of bodies, was studied, as was also the effect of the temperature to which the specimens had been heated. The most important conclusions justified by the data obtained are as follows: (1) Fused feldspar is the most susceptible to moisture expansion of the materials investigated. (2) The increasing content of fused feldspar and the decreasing absorption of whiteware bodies heated to progressively higher temperatures are counteracting influences which apparently result in least resistance to moisture expansion for those bodies matured at cone 6 to 8 and having an absorption of about 10%. (3) Glazed earthenware may be subject to crazing caused by penetration of moisture through the glaze and the resultant

moisture expansion of the body. (4) Reactions induced by heating autoclaved specimens and evidenced by contraction are relatively sluggish at 120 °C, they proceed faster as the temperature is raised, and are markedly accelerated at temperatures above 230 °C. (5) Autoclaved specimens of white ware which have expanded due to reaction with moisture apparently return to their original length when cooled to room temperature after being held for a reasonably short time at 250 to 270 °C in air and under atmospheric pressure. See also *Ceram. Abs.*, **10** [1], 67 (1931) and following abstract. R.A.H.

Contribution to the question of water expansion of white ware. K. TRAUTMANN. *Ber. deut. keram. Ges.*, **13** [7], 316–22 (1932).—Some comparative tests with different steam pressures in autoclaves to determine the water expansion of whiteware bodies were made. The results on a limited number of specimens are given and the need of further work is pointed out. E.J.V.

Alteration of the homogeneity of porcelain bodies. M. W. FLEROV. *Ber. deut. keram. Ges.*, **13** [6], 257–68 (1932); for abstract see *Ceram. Abs.*, **11** [3], 188 (1932). E.J.V.

High-voltage insulators. W. HOWARD MILLER. *Elec. Rev.*, **111** [2857], 278–79 (1932).—The design and assembly of multipart insulators call for the greatest of care. Porcelain, a relatively inelastic medium having a low tensile strength and a high strength in compression combined with an extremely low-temperature coefficient, has to be joined part to part and part to sections of metal having widely differing characteristics. The only satisfactory media for the assembly of the material have in themselves characteristics differing from either porcelain or metal. In insulators of relatively large diameter and horizontal surfaces a marked tendency toward radial cracking must exist. This may well be relieved by forming a bulbous section at the outer rim which at the same time relieves electric stress at this point. Electrical tests of the unassembled shells should be of the utmost severity. Sound porcelain has nothing to fear from a severe testing. No testing specification should omit tests at 200,000 cycles nor those with steep-fronted impact cycles. In every case where porcelain with sufficient thickness for the test concerned has failed under these tests, there has been positive evidence of concealed faults. The normal frequency test specified in British Standard Specification No. 137/1930 will make no impression on shells containing laminations or internal flaws unless the flaws are of a serious nature. Raising the applied voltage until a condition of violet sparkover with bright bluish sparks is attained raises the standard of the test to a remarkable degree without risk of damage to sound material. E.P.R.

Mechanical strength of ceramic insulators exposed to electric shocks. K. DRAEGER. *Arch. Elektrotech.*, **26** [8], 597–610 (1932).—Experiments show the influence of the type of voltage, temperature, polarity, and time of shock in homogeneous and nonhomogeneous fields. Specially made samples and technical products were tested. In some cases only partial destruction was observed. The best form against shock is a rounding off of all points and edges. The insulators should be made in one piece only, if possible. W.M.C.

Electrical breakdown of solid insulators. R. WIDEROE. *Arch. Elektrotech.*, **26**, 626–31 (1932).—The electrical breakdown is supposed to be caused by an ionization by impact. Using the known data of the lattice energy and the radii of the ions of sodium chloride, the limits of the breakdown field are calculated. The results of the calculation are found to agree satisfactorily with the experiments. W.M.C.

Size control in the manufacture of porcelain insulators. E. H. FISCHER. *Ceram. Ind.*, **19** [4], 184–85 (1932).—F. discusses size control in the manufacture of porcelain insulators and gives data on shrinkage and shrinkage allowances. W.W.M.

Stress problems overcome in cemented insulators. E. H. FRITZ. *Elec World*, **100** [7], 221–22 (1932).—Studies were made of (1) the behavior of cement with and without resilient coatings on the porcelain insulator, and (2) the effect of changes in the porcelain design, considering particularly the angles of slope between two porcelain parts cemented together, as found in a multipart pin-type insulator. Results are discussed in detail. G.R.S.

Nonsiliceous porcelain with a pure fluorite base. A. DAMIENS. *Chim. & ind.* [Special No.], pp. 493–95 (March, 1932).—D. gives researches and results obtained and describes a fluorite electric furnace. See also *Ceram. Abs.*, **11** [3], 188 (1932). M.V.K.

Pour marks on porcelain. ANGELO CASTIGLIONI. *Industria chimica*, **6**, 1260–65 (1931).—K. discusses the appearance of pour marks on porcelain and attributes them to the fact that a small part of the clay is present as a colloidal solution rather than in suspension. M.V.K.

Operation control and quality testing in the mosaic tile industry. HANS LEHMANN

AND URSULA WERTHER. *Ber. deut. keram. Ges.*, **13** [7], 281–316 (1932).—This treatise takes up the chemical, physical, and technical questions in the manufacture of mosaic tile. The mosaic tile body is prepared by three processes which are described and the advantages and disadvantages of each are pointed out. Finally, the authors describe the pressing, drying, setting in saggers, firing, and sorting of the tile. The quality of the finished product is largely dependent on the proper selection of the raw materials. The methods for testing the chemical and ceramic properties are described and the results of testing typical raw materials for the production of mosaic tile are compiled. Next to the choice of raw materials in its influence on the finished product is the fineness and thorough homogenizing of the mixture of raw materials. Several methods of determining the degree of fineness which are available to the ceramic operator are described. Comparative analyses were made with the Gonell laboratory air separator and pipette apparatus. These showed that this special apparatus could be used for testing the dry prepared material although the cheaper and simpler pipette apparatus can also be used for comparative tests. The description of the production methods follows that of the testing of the finished product. The requirements set for mosaic tile are density, strength, and acid and frost resistivity. Four known methods for determining the density were tested with the result that the boiling method was proven to be the most rapid, simplest, and most reliable. Tests of resistance to compression and to torsion were made on a large number of different mosaic tile and the results are discussed. The tests used for the control of acid stability and safety against frost showed that mosaic tile, which showed the typical properties of vitrified bodies, were stable toward acids and alkalis as well as capable of enduring freezing tests of long duration at −25° without any damage. As a special test for mosaic tile, the determination of reflecting power is undertaken as the consumers who use the tile for operating rooms have set definite standards for the reflecting power of the wall and floor tile. Illustrated. E.J.V.

PATENTS

Electric insulator. W. D. KYLE (Line Material Co.). U. S. 1,877,903, Sept. 20, 1932.

Method and apparatus for producing tile. R. B. KEELER AND R. W. PHILLIPS. U. S. 1,878,780, Sept. 20, 1932.

Closet bowl with spray receptor. L. B. STINE (Crane Co.). U. S. 1,878,910, Sept. 20, 1932.

Dripless spout for pouring vessels of ceramic material. CHRISTOPH ACHTZIGER (Porzellanfabrik Weiden Gebr. Bauscher). U. S. 1,878,996, Sept. 27, 1932.

Tile-surfaced structural element. J. F. DOVEN (American Tile Fixture Co., Inc.). U. S. 1,880,015, Sept. 27, 1932.

Tiled wall construction. HENRY RITHNER. U. S. 1,880,282, Oct. 4, 1932.

Water closet. J. M. TEAHEN AND WILLIAM TAYLOR. U. S. 1,880,298, Oct. 4, 1932.

Drainless closets. E. M. GINDERS. Brit. 380,490, Sept. 28, 1932.

Equipment and Apparatus

Control of plasticities of ceramic slips. WALTER L. SHEARER. *Jour. Amer. Ceram. Soc.*, **15** [11], 622–29 (1932).

Inner structure of solid inorganic compounds at high temperatures. Electrical conductivity, diffusibility, and reactivity of magnesium orthosilicate and magnesium orthogermanate in the solid state. WILHELM JANDER AND WILHELM STAMM. *Z. anorg allgem. chem.*, **207** [3], 289–307 (1932).—From measurements of the electrical conductivity and diffusibility of Mg_2SiO_4 and Mg_2GeO_4 the authors draw conclusions as to the internal structure of the compounds at high temperatures. They find that Mg_2GeO_4 has a transition point at 1065°, above which it is isomorphous with olivine and below which it has a spinel structure. The spinel structure shows a greater conductivity than the olivine type. In the spinel structure conductivity is partly ionic; in the olivine type it is apparently electronic. The diffusion of germanium into Mg_2SiO_4 between 1070 and 1200° is rapid. Mg_2SiO_4 crystallizes in a double oxide lattice. A more detailed discussion of the structures follows. See also *Ceram. Abs.*, **11** [1], 62; [4], 268 (1932). L.T.B.

Gas-fired furnace. DENVER FIRE CLAY CO. *Chem. Met. Eng.*, **39** [6], 347 (1932); for abstract see *Ceram. Abs.*, **11** [10], 538 (1932). G.R.S.

Industrial electrical oven. ANON. *Chem. Met. Eng.*, **39** [8], 459 (1932).—Control of vapor pressure, humidity, and temperature at any desired value within a wide operat-

ing range are features of a new temperature-control cabinet for experimental and plant work in drying, firing, evaporating, and other operations. The cabinets employ forced-air circulation, are completely self-contained, and are available in a standardized series of sizes for maintaining dry- and wet-bulb temperatures in approximately the range from 5° above room temperature to 150°F. Vapor pressures that can be maintained range from 0.5 to 4.5 in. of mercury above atmospheric pressure. G.R.S.

Melting furnace. G. Zotos. *Feuerungstechnik*, **20** [9], 135–36 (1932).—A new melting furnace built according to the method of Zotos is described in detail. M.V.K.

Determining the melting point of minerals in an electric short-circuit furnace. O. Weigel and F. Kaysser. *Glastech. Ber.*, **10** [8], 443 (1932); for abstract see *Ceram. Abs.*, **11** [7], 417 (1932). M.V.K.

Voltage regulator for furnace control. Vaughan W. Stott. *Jour. Sci. Instruments*, **8** [10], 313–16 (1931).—A simply constructed regulator capable of maintaining a constant "root mean square" voltage for long periods in the circuit of an electric-resistance furnace is described. Essentially, it consists of a mercury thermometer in whose ends platinum wires have been sealed. Contact is made between these when the mercury expands to the 125°C position. A heating-coil wound on the bulb of the thermometer is shunted across the points in the furnace circuit where voltage control is required. The platinum wires are connected to the input side of a delicate relay containing a mercury tilting switch. The output side of the relay is connected with the furnace circuit so that contact by the mercury between the platinum wires reduces the main furnace current. A sketch of the thermometer set-up and a schematic diagram of the electrical circuits are given. J.L.G.

Dilatometer. W. E. Prytherch. *Jour. Sci. Instruments*, 9 [4], 128–31 (1931).—P. uses an oscillating valve circuit to correlate the thermal dilatation of short metal specimens with temperature changes. Expansion or contraction of the specimen moves a small condenser plate, the other plate of the condenser being fixed. The condenser forms part of the series grid capacity of the circuit and hence small changes in the capacity of the condenser cause relatively large changes in the anode current of the valve. Continuous records of the anode current and of the temperature of the specimen are made simultaneously on a Cambridge Thread Recorder. Thus length changes are correlated with the temperature of the specimen. A Hartley type oscillator was used. Two schematic diagrams, a sketch of the furnace set-up, and two typical dilatation curves are included in the paper. Difficulties were encountered in attempting to measure the absolute values of length changes. These are due in part to a gradual creep in the zero of the recorder associated with drift in valve characteristics. The apparatus is sensitive to detect changes of length of less than a millionth of an inch. The absolute accuracy, however, falls far short of this value and decreases with increase of the measuring period. J.L.G.

Apparatus for the continuous recording of p_H. I. General description. A. E. J. Vickers, J. A. Sugden, and R. A. Bell. *Chem. & Ind.*, **51** [26], 545–54 (1932).—The apparatus is well constructed and simple to operate. It was built primarily in connection with the measurement of the p_H of clays and soils. **II. Principles of design of thermionic potentiometers.** *Ibid.*, **51** [27], 570–74 (1932).—A number of valves were tested and a list is given of those recommended for use in the thermionic potentiometer. G.R.S.

Portable thermionic electrometer for the determination of glass-electrode potentials. C. Morton. *Jour. Sci. Instruments*, **9** [9], 289–93 (1932).—A portable thermionic electrometer with self-contained potentiometer, standard cell, and rugged pointer galvanometer is described. Illustrated. J.L.G.

Quartz double monochromator and vario-illuminator with mirrors (instead of lenses) for the region of 0.2 to 3mμ. Carl Leiss. *Z. Physik*, **77** [5–6], 412–14 (1932).—A new quartz double monochromator is described in which mirrors with great reflectivity in the ultra-violet are used, so that focusing for different wave-lengths is no longer necessary. L.T.B.

Objective micropyrometer. G. Lewin, W.-W. Loebe, and C. Samson. *Z. tech. Physik*, **13** [9], 415–20 (1932).—A new micropyrometer is described for measuring the temperature of incandescent bodies down to a diameter of 5μ. An amplifier is used with the new instrument. The lower limit of the measuring range is about 1450°K using a 50-fold magnification and 1780°K using a 140-fold magnification. The accuracy of measuring is ±10° at 2490°K. W.M.C.

Cooling of Globars using photographic pyrometers. R. Hase. *Z. tech. Physik*, **13** [9], 410–15 (1932).—Temperature measurements can be made by photography if the effective wave-length is known. By an interpolation using gradation steps and photo-

electric photometers, the rapid cooling of Globars and similar processes can be measured with considerable accuracy. For intervals of more than 100°, monochromatic light should be used. W.M.C.

Total refractometer. A. W. TRONNIER. *Z. tech. Physik*, **13** [9], 402–406 (1932).—The new refractometer is built in such a way that the index of refraction of the measuring prism is eliminated. Different types of instruments are available according to the investigations carried out. W.M.C.

Optical pyrometer with three-range telescope. ANON. *Elec. World*, **100** [6], 192 (1932).—The indicator has a direct-reading scale with two ranges, 1100 to 2600°F and 2200 to 3700°F. For the third range a conversion table is supplied. The rheostat for controlling the lamp current is contained in the telescope. This makes it easy to keep the telescope pointed at the object because both hands hold and direct the telescope when making the measurement. The indicator weighs only 5 lb. and measures 6x6x3 in. G.R.S.

Manometric apparatus for mechanical analysis of soils and other disperse systems. A. N. PURI. *Soil Sci.*, **34** [2], 115–21 (1932).—The apparatus is described. It is based on the principle of the differential liquid manometer, having a mixture of aniline and benzene (of density slightly greater than water) as the heavier liquid and water itself as the lighter liquid. G.R.S.

Microscopical investigation of minerals and rocks. N. VEDENEEVA. *Mineral. Suir'e*, **6** [12], 1087–92 (1931).—Different apparatus used for microscopical investigations are described. M.V.K.

Precision photo-electric controller. C. W. LA PIERRE. *Mech. World*, **92** [2383], 218 (1932).—This article describes the first application of a new photo-electric controller which has been developed in America by the General Electric Co. It may be used for the control of processes for which hitherto only extremely delicate instruments have been available. E.P.R.

Progress in testing of materials by X-rays. A. HERR. *Schmelzschweissung*, **10** [11], 258–62 (1931); abstracted in *Metals & Alloys*, **3** [6], 166 (1932).—It is noted that, for very valuable objects, the X-ray investigation should not be restricted to the finished product but should start during the early manufacturing process. This will often save expensive repairs while the testing in earlier stages requires only a negligible outlay. The safety of operation, economy, and reliability of X-ray testing as applied with modern apparatus is discussed and illustrated by examples. E.P.R.

Methods and results of the X-ray investigation of sub-crystalline materials. I–II. F. D. MILES. *Jour. Soc. Chem. Ind.*, **51** [31], 247–55 (1932).—X-ray apparatus and methods and X-ray diffraction diagrams and their significance are described. G.R.S.

Constant-temperature cells for microscopic observations. J. B. M. COPPOCK, J. COLVIN, AND J. HUME. *Chem. & Ind.*, **51** [34], 700–701 (1932).—Two cells are described which were used for microscopic observations and for obtaining photomicrographs of the decomposition of crystals at constant temperature. G.R.S.

Use of electron tubes. W. R. KING. *Maintenance Eng.*, **90** [10], 377–79 (1932).—Electron tubes are being used in the factory to count parts, operate switches, and control welding machines. Illustrated. J.L.G.

Electrostatic precipitation in industry. H. W. WAGNER. *Glass*, **9** [8], 352–53 (1932).—Removal of dust from gases by electrostatic means is outlined. G.R.S.

Expansion of metals at high temperatures. F. L. UFFELMANN. *Phil. Mag.*, **10**, 633–59 (1930).—The thermal expansion coefficients of tin, cadmium, zinc, lead, aluminium, copper, brass, cobalt, nickel, and steel were measured by an interferometer method up to 700°C. The course of the expansion curves for all of the metals did not fit either the quadratic or Thiesen's formulas. Different changes in slope of the temperature-expansion curves are observed for some of the metals. J.T.L.

Continuous filtering and drying of pottery slip. L. A. MITCHELL. *Trans. Ceram. Soc.* [Eng.], **31** [8], 288–94 (1932); for abstract see *Ceram. Abs.*, **11** [6], 380 (1932). C.G.H.

Application of stellite. J. L. SPENCE. *Clay Prod. News*, **5** [2], 1–3 (1932).—S. cites the use of stellite beads around the periphery on the foreward face of the augers in the plant of the Sun Brick Co., Ltd. This procedure increased the life of the augers from about 30 days to 6 or 7 months. The wearing edges of other machinery and tools were stellited with similar results. W.W.M.

Investigations by the Physikalisch-Technischen Reichanstalt in the region of low temperatures. F. HENNING. *Z. Ver. deut. Ing.*, **76** [24], 577–80 (1932).—Apparatus for making measurements at low temperatures, from 1 to 200°K, is described. The methods for measuring the temperatures are given. L.T.B.

Dual voltage connections for induction motors. A. C. Roe. *Maintenance Eng.*, **90** [10], 384–86 (1932).—Series and parallel connections for two-phase, four- to ten-pole motors are considered. Illustrated. See also *Ceram. Abs.*, **11** [10], 537 (1932). J.L.G.

High-pressure lubricating systems. Fred H. Low. *Maintenance Eng.*, **90** [10], 392–93 (1932).—A high-pressure lubricating system for handling plastic heavy-body greases is described. It is operated by an air pressure of 80 to 100 lb. and is electrically controlled. Illustrated. See also *Ceram. Abs.*, **11** [10], 544 (1932). J.L.G.

Contact rails for cranes and loading plants. P. Vahle. *Eng. Progress*, **13** [9], 204–205 (1932).—A copper-headed steel contact rail is described which eliminates the difficulties of the insufficient stability and consequent uneven and premature wear experienced when trolley wires are used for contacts. Illustrated. J.L.G.

Air compressors. F. T. Harrison. *Ind. Finishing*, **8** [11], 7–10 (1932).—Selection, installation, relative advantages of water- and air-cooled compressors, lubrication, pipe drainage, precipitation of moisture in the line, and prevention of precipitation at the gun by heating at this point are considered. J.L.G.

Determining minimum air velocities for exhaust systems. J. M. Dallavalle. *Heating, Piping, Air Conditioning*, **4** [9], 639–41 (1932).—The minimum air velocities required to transport different materials are considered. Equations and charts are given. J.L.G.

Lifting chain maintenance. Benjamin Hantman. *Maintenance Eng.*, **90** [10], 380–83 (1932).—The inspection and maintenance of sling chains are described. Illustrated. J.L.G.

Rotax electric controller. Foxboro Co. *Glass Ind.*, **13** [10], 172 (1932); *Gas Age-Rec.*, **70** [13], 325 (1932).—The new electrically operated control instrument with commutator type contacts is used to control temperature, pressure, humidity, flow, or liquid level and to give audible or visible signals. It is designed to operate valves, compressors, blowers, motors, heating units of all kinds, horns, lights, and other electrical equipment, and has a wide variety of industrial applications. Illustrated. E.J.V.

Heating by forced hot water. H. H. Angus. *Heating, Piping, Air Conditioning*, **4** [9], 642–44 (1932).—The topics considered are the advantages of forced circulation, pumps and motive power, boilers for hot water systems, heating surface and water temperatures, piping layout, freezing of water in radiators, repairs, comparative costs, and adaptation to fluctuating conditions. J.L.G.

Fan erosion by dust particles. Anon. *Chem. News*, **145** [3778], 157 (1932).—A study was made of the erosion of fans by the action of dust particles suspended in combustion gases. G.R.S.

Large scale industrial filtration; rotary vacuum filters. H. Manger. *Dechema Monographien*, **4** [38–47], 65–96 (1931); *Chim. & ind.*, **27** [6], 1301 (1932).—The operation of a rotary vacuum filter and the selection of a suitable filter medium are discussed. M.V.K.

Device for revolving oval objects. Ernst Brückner. *Sprechsaal*, **65** [34], 621–22 (1932).—A device for simplifying the shaping of oval objects is described. M.V.K.

Maintenance of pulverized parts. M. C. Carver. *Power*, **74** [12], 893 (1931); abstracted in *Metals & Alloys*, **3** [8], 248 (1932).—Heat treatment of coal-pulverizer hammers increased life from 3 to 15 months. Surfacing or plating had no effect. E.P.R.

Pumps for high vacuum. Anon. *Mech. World*, **92** [2383], 216 (1932).—A high degree of vacuum hitherto obtainable only in the laboratory is now possible on a commercial scale, 0.00001 mm. off perfect being a normal figure. The pumps are being applied to a number of industrial uses. E.P.R.

Recorded weights to maintain quality of porcelain ware. Ralph P. Brown. *Ceram. Ind.*, **19** [4], 174–75 (1932).—B. describes a special batch-weight scale, used by the Champion Porcelain Co., which prints weights on a record sheet automatically. This eliminates errors which might be serious. W.W.M.

Belt conveyer theory and practice. III. Belt conveyer drives. G. F. Dodge. *Rock Prod.*, **35** [18], 62–64 (1932).—D. discusses conveyer drives, including the simple level conveyer, simple inclined conveyer, internal drive, internal tandem drive, head tandem drive, theory of the tandem drive, inverted tandem drive, hugger drive, and unity factor drive. Sketches of each type of drive are shown and a table of drive coefficients is given. For Part II see *Ceram. Abs.*, **11** [6], 379 (1932). W.W.M.

Preparing work for polished chromium plating. W. E. Warner. *Can. Machinery*, **42** [11], 23 (1931); abstracted in *Metals & Alloys*, **3** [8], 245 (1932).—Where Cr plating has to be polished, the preparation of the underlying metal is important. The article

should be first polished with No. 46 emery using a speed of 8500 ft./min. Successively finer grades of emery should then be employed; no grease should be used with the emery. When buffing, a speed of 14,000 ft./min. at least should be used, tripoli should be the abrasive, and grease used as a lubricant. The piece is then cleaned in an alkali bath, rinsed, and plated. If the part is to be plated with Ni or Cr first, it should be buffed before final Cr plating. If this procedure is used, the Cr plating will appear bright and polished on leaving the bath and at the most, only a slight buffing will be necessary. E.P.R.

Air conditioning the Detroit Edison Building. J. N. LIVERMORE AND P. S. HOSMAN. *Heating, Piping, Air Conditioning*, **4** [9], 593–97 (1932).—A system of air conditioning designed and installed in a research laboratory is described. Illustrated. J.L.G.

Large drying plant. A. JÓNÁS. *Tonind.-Ztg.*, **56** [60], 755–56; [62], 780–81 (1932).—Different types of large drying plants are described. The installation and running costs of a large drying plant using the waste heat of a ring kiln are given. W.M.C.

BOOKS

Chromium Plating. E. S. RICHARDS. 136 pp. Price $3.50. *Metal Cleaning & Finishing*, **4** [9], 517 (1932).—R. covers thoroughly the plating shop and its equipment, the polishing shop and rough polishing, copper plating, nickel plating, chromium plating aluminum, wood, plaster, glass and other materials, finishing polish for chromium plating, and protection of the workers. E.J.V.

Modern Materials Handling. SIMEON J. KOSHKIN. Published by John Wiley & Sons, Inc. Reviewed in *Abrasive Ind.*, **13** [10], 20 (1932).—K. treats and analyzes modern methods of handling different kinds of materials and deals with the principles and considerations involved in the proper selection of the method of handling any kind of material. E.P.R.

Correct Machine Lubrication. (Richtigie Maschinenschmierung.) E. W. STEINITZ. J. Springer, Berlin. 177 pp. Paper, 7.80Rm. *Mining & Met.*, **13** [310], 9 (1932).—The properties of lubricants and the conditions for proper lubrication are considered briefly. The lubrication of different types of engines, turbines, and different kinds of machinery used in various industries is discussed. E.J.V.

PATENTS

Process and apparatus for separating materials. L. A. HATCH (Minnesota Mining & Mfg. Co.). U. S. 1,877,861, Sept. 20, 1932.

Clay-tempering means and method. A. F. C. LOTZ (Ceramic Development Corp.). U. S. 1,879,367, Sept. 27, 1932.

Method of producing high temperatures. R. G. WULFF. U. S. 1,880,306, Oct. 4, 1932. An intermittent endothermic process comprises burning a gas mixture containing oxygen and an oxidizable gas within the interstices of a porous refractory material, then, after the porous material has been heated to a high temperature, electrically heating the porous material until a further materially higher temperature is reached, discontinuing the flow of the mixture and electricity, and passing a gas or vapor which reacts endothermically through the porous material.

Hydraulic clay molding machine. F. Y. PEARNE AND WILLIAM MCCLINTOCK (F. R. Galbreath). U. S. 1,881,061, Oct. 4, 1932.

Manufacture of building brick, tile, etc., from plastic clay. T. S. BLYTHE. Brit. 379,603, Sept. 7, 1932.

Kilns, Furnaces, Fuels, and Combustion

Molecular fragments and oxidation processes. JOHN R. BATES. *Jour. Chem. Ed.*, **9** [7], 1219–25 (1932).—Evidence is presented to show how important atoms and radicals are becoming in the concept of the steps by which chemical reactions take place. Specific examples of oxidation which are beginning to be understood on this basis are discussed together with the general grounds for assumptions of the existence of such molecular fragments. A.K.

Similitude and heat flow through a granulated material. O. A. SAUNDERS. *Phil. Mag.*, **13**, 1186 (1932).—A short discussion is given of the heat flow through granulated materials. In the case of heat flow by conduction in a heterogeneous body the case is considered in which the particles are conducting bodies. A conclusion is reached that if the heat transfer across the air spaces in a granulated material is by conduction alone the effective conductivity will be independent of the linear size of the grains. Neglect-

ing the conductivity of the air, the effective conductivity will be proportional to that of the solid material. If the grains are perfectly conducting the effective conductivity will be proportionate to the grain size. J.T.L.

Temperature distribution of bodies heated by high-frequency currents. U. SCHWEDLER. *Arch. Elektrotech.*, **26** [8], 553–56 (1932).—The distribution of energy and temperature is calculated for a body of infinite length heated by a high-frequency current. The influence of the diameter on the temperature distribution of a high-frequency furnace is shown. The calculation of the temperature for the insulation proves that the insulating materials have a great influence on the temperature of the inside of the furnace. W.M.C.

Change of periodic kilns into zigzag kilns. L. SCHIELE. *Tonind.-Ztg.*, **56** [73], 915 (1932). W.M.C.

Small size tunnel kilns. ANON. *Tonind.-Ztg.*, **56** [70], 878–80 (1932).—In recent years the tunnel kiln has been adapted for use in small plants. A number of tunnel kilns are shown using cars or conveyers for loading the product. Illustrated. W.M.C.

Tunnel-kiln cars for recording the temperature. PRADEL. *Tonind.-Ztg.*, **56** [60], 757–58 (1932).—Special cars are provided for tunnel kilns, which carry no ceramic products but only several recording instruments and which, from time to time, are passed through the kiln to measure the temperature distribution. W.M.C.

Modern method of firing: the Lepol furnace. WILHELM EITEL, KARL GOSLICH, AND ALFRED MULLER. *Rev. mat. constr. trav. pub.*, No. 275, pp. 326–33 (1932).—The operation and efficiency of the Lepol furnace is described in detail. Tables and diagrams illustrate the article. M.V.K.

Water-smoking by using the chimney draft of chamber, ring, and zigzag kilns. P. THOR. *Tonind.-Ztg.*, **56** [67], 838–40 (1932).—The amount of heat which can be drawn out of the kiln is discussed. A table gives the cost of water-smoking for a large number of kilns, together with their output. The amount of heat available and the temperature of water-smoking are discussed in detail. See also *Ceram. Abs.*, **11** [6], 382 (1932). W.M.C.

Faults in the water-smoking of brick. ANON. *Tonind.-Ztg.*, **56** [66], 823–24 (1932).—In many cases, defects in the furnace construction give bad results when brick are being water-smoked. The importance of installing instruments for controlling the draft of the furnace and its temperature is outlined. W.M.C.

Fuels, solid, liquid, and gaseous. NORTON H. HUMPHRYS. *Gas Eng.*, **49** [10], 495–96 (1932).—The desirability of preliminary gasification of fuel, the "value" lost in smoke, heat losses, impurities in solid fuels, combustible matter, and the air supply to grates are the topics discussed. J.L.G.

Determination of the fusion temperature of coal ash. ANON. *Queensland Mining Jour.*, **33** [7], 246 (1932).—It is well known that the ash present in coal may be objectionable for furnace purposes because of its relative fusibility and liability to clinker. Generally, there is some connection between the fusion point of the coal ash and the tendency to clinker, but there is little reliable data establishing the relations between the laboratory test and the furnace. A definite step has been taken in the correlation of the fusion temperature of coal ash with practical furnace conditions in the issue by the British Standards Institution of the standard method for the determination of the fusion temperature of coal ash. The method, which is based on experiments, is described in Fuel Research Technical Paper No. 23, 1929, and briefly in this article. E.P.R.

Mechanical methods of coal cleaning. W. WILSON. *Meck. World*, **92** [2380], 141–42 (1932).—In addition to hydraulic and pneumatic methods of cleaning coal there are two mechanical methods which are not dependent on the specific-gravity characteristics of the materials. These methods are based on the relative frictional and resilient properties of the coal and the material to be separated from it. Coal has a coefficient of friction less than that of shale. This characteristic is used in the spiral separator to effect the segregation of coal and shale. The coal-separating threads, in addition to having their downward spiral inclination, also have an inward inclination toward the center post. When a particle commences to slide down a separating thread it is subject to the following forces: (*a*) the downward component of the gravitational pull due to the inclination of the thread downward; (*b*) the inward component of the gravitational pull due to the inward inclination of the thread; (*c*) the centrifugal force due to the spiral motion round the center post; (*d*) the retarding force due to the friction. When the centrifugal force is great enough to overcome the resultant force of the other three, the moving particle gradually travels outward and falls over the rim of the thread. E.P.R.

Pulverizing coal of high moisture content. ANON. *Power Plant Eng.*, **36** [18], 710–11 (1932).—Paper-mill installation successfully handles local strip mine coal with 14% moisture and low fusion-temperature ash. The system is briefly described. E.P.R.

Present-day tendencies in design and operation of coal-preparation plants. H. B. COOLEY. *Can. Mining Met. Bull.*, No. 242, p. 283 (1932).—The paper deals with (1) aspiration or de-dusting, (2) picking facilities, (3) labor saving, (4) pressure lubrication, (5) gate operation, (6) prevention of breakage, (7) conveyer drives, and (8) accessibility of every operating part of the plant to facilitate daily care and repairs. G.M.H.

S. V. I. classification of coals. EDITORIAL. *Can. Mining Met. Bull.*, No. 241, p. 195 (1932).—A new method of coal classification has been developed in the Dominion Government Mines Branch, the special feature of which is the S. V. I. (specific volatile index) ratio which is defined as

$$\frac{\text{Determined B.t.u. per lb. of coal–per cent fixed carbon} \times 14{,}500}{\text{Per cent volatile matter}}$$

The S. V. I. is mainly for the classification of coals for use in the by-product coking industry but is admirably adapted for the classification of all varieties of coal since it has a wide range (from below 80 for peat to above 215 for semi-anthracite). G.M.H.

Coal-cutting machines. A. F. CAGNEY. *Can. Mining Met. Bull.*, No. 242, pp. 267–82 (1932).—An interesting study is made of types and operation of coal-cutting apparatus. G.M.H.

Gas from hard coal. ANON. *Amer. Glass Rev.*, **52** [1], 25 (1932).—The Anthracite Institute in Philadelphia has developed a machine for the manufacture of commercial gas from anthracite or hard coal. The machine has been in operation at the Institute's laboratory at Primos, Pa., and is said to produce gas equivalent to ordinary city gas at 20¢ per thousand cubic feet. Use of the machine in industries where a standardized fuel is required will be pushed. E.P.R.

Gas in industry. H. LENT. *Gas Wasserfach*, **74** [9], 873–77; [9], 905–908 (1931); abstracted in *Metals & Alloys*, **3** [7], 224 (1932).—The speaker at the 72nd General Meeting of the Deutscher Verein von Gas- und Wasserfachleuten, June, 1931, Breslau, discussed the great advances of gas firing as a coming competitor of electric heat in industry. Attention is focused on the characteristics and advantages of both kinds of heat applied to industrial furnaces. After a general discussion of the subject, L. takes up the various types of gas-fired furnaces. E.P.R.

Gas firing improves efficiency of British potteries. A. C. B. *Gas Age-Rec.*, **70** [14], 340 (1932).—The Fairfield Pottery, Hanley, recently installed a gas-fired oven operating on the regenerative principle. Saggers are eliminated, firing costs are cut from 7½ to 5% of the selling price, "rejects" have been halved, furnace maintenance charges are reduced to a negligible sum, and operating time for filling an order has been cut from 14 days to 3 days. E.J.V.

Making accurate heating-value determinations on gases. E. X. SCHMIDT. *Gas Age-Rec.*, **70** [13], 303–307 (1932).—The effect of gas composition on the accurate determination of heating values with water-flow calorimeters is discussed in detail, the various precautions necessary in connection with each phase of the determination being enumerated. E.J.V.

Gas and oil fields in map. ANON. *Amer. Glass Rev.*, **51** [50], 12 (1932).—A map of the U. S. showing the oil and gas fields, recently published by the Geological Survey, Dept. of the Interior, may be purchased from the Director of Geological Survey, Washington, for $1.00. E.P.R.

Glass plant fuel-oil systems. JOHN W. ROMIG. *Glass Ind.*, **13** [10], 159–62 (1932).—The fuel-oil system must be fitted to meet the requirements of the oil and at the same time render, regardless of the viscosity, equally satisfactory combustion results when applied to production. A fuel-oil system should handle viscous fuel oils during cold weather and be as free from trouble as during warm weather. The handling of fuel oil may be classed in five major operations: (1) unloading from car to storage, (2) storing and transfer from tank to tank, (3) delivery to service system, (4) delivery to burners, and (5) atomizing and burning in combustion chambers. Detailed descriptions of the systems to be used in carrying out these operations are given. Illustrated. E.J.V.

Relationship of theory and experience in industrial drying and processing. VI. Fuels for general drying and methods of selection. C. F. MAYER. *Fuels & Fur.*, **10** [8], 534–38 (1932).—The proper selection of fuel for industrial ovens depends on the following important factors: (1) adaptability of fuel to work processed, (2) methods of

application, (3) B.t.u. efficiency and fuel costs, and (4) installation investment, interest, depreciation, and maintenance. These points are discussed thoroughly. Illustrated. For Part V see *Ceram. Abs.*, **11** [10], 536–37 (1932). E.J.V.

Improvement of obsolete brick plants. L. SCHIELE. *Tonind.-Ztg.*, **56** [63], 792 (1932).—S. deals with the conversion of a noncontinuous kiln to one with continuous operation. W.M.C.

Soot. ANON. *Feuerungstechnik*, **20** [9], 129–30 (1932).—The formation and composition of soot are discussed. M.V.K.

Nova Scotia and the coal-mining industry. F. W. GRAY. *Can. Mining Met. Bull.*, No. 244, pp. 427–29 (1932).—Lines along which development must proceed are (1) fewer and larger mines, (2) electrification of all operations, (3) total extraction of the seam as nearly as possible in one operation, (4) greater use of long wall faces, (5) more powerful coal cutters, (6) production of coal with less shooting, (7) in the submarine field greater use of lateral haulages, (8) larger coal cars underground, (9) use of steel arching, props, and strapping to supersede timber for roof support, and (10) mechanical coal cleaning. G.M.H.

Advance in mechanization in collieries of the Sydney coal field. A. S. MACNEIL AND JOS. KALBHEEN. *Can. Mining Met. Bull.*, No. 242, p. 289 (1932).—As complete mechanization as conditions will permit has been aimed at with resultant lowered costs. G.M.H.

BOOKS AND BULLETINS

Smoke: A Study of Aerial Disperse Systems. R. WHYLAW-GRAY AND H. S. PATTERSON. 192 pp. E. Arnold and Co., London, 1932. Reviewed in *Chem. & Ind.*, **51** [29], 618–19 (1932).—The formation of smokes under controlled conditions by the dilution of a small quantity of hot vapor by a relatively large volume of cold air is discussed. Methods are described for measuring the size of the particles, their mass, and the number of them in unit volume. The subsequent history of the newly formed particles, as observed in the ultramicroscope, the rate of growth, the manner of growth, and the structure of flocculation or coagulation are fully treated. One chapter describes the structure of smoke particles of different materials. The book is well illustrated and clearly written. G.R.S.

Examination of Fuels and Their Roenner Evaluation. (Die Untersuchung der Brennstoffe und Ihre Roennerische Auswertung.) M. DOLCH. Wilhelm Knapp, Halle (Saale), Germany. 252 pp. Price, paper, 18.50 Rm. *Mining & Met.*, **13** [310], 9 (1932).—This book is designed for the fuel chemist who is called upon to determine from analyses the suitability of a coal for various industrial purposes. The appropriate methods of analysis are described in detail and their bearing on the value of the coal is discussed. D. shows how the analytical data may be used to calculate the yield of tar, gas, and coke and the economic possibilities of the fuel. E.J.V.

Removal of soot from furnaces and flues by use of salts or compounds. P. NICHOLLS AND C. W. STAPLES. Bur. Mines *Bull.*, No. 360. 76 pp. 10¢ from Supt. of Documents, Govt. Printing Office, Washington, D. C. A list of compounds which have been proposed, patented, or sold for this purpose is included. A detailed report of tests made and results obtained is also given. R.A.H.

Heat transfer from a gas stream to a bed of broken solids. C. C. FURNAS. Bur. Mines *Bull.*, No. 361. 88 pp. 10¢ from Supt. of Documents, Govt. Printing Office, Washington, D. C. The report presents data on heat transfer from a gas stream to a bed of broken solids for a considerable range of materials, particle sizes, gas velocities, and temperatures in a general form so that they may be applied to any type of system studied. R.A.H.

Furnace Technical Calculations. (Feuerungstechnisches Rechnen.) WILHELM GUMZ. 8.00Rm. Reviewed in *Sprechsaal*, **65** [34], 634 (1932).—The book deals with (1) fuel, (2) combustion, (3) efficiency and heat losses, (4) heat diagram, (5) heat transfer, (6) processes of flow, (7) obtaining draft, and (8) gas-technical calculations. See also *Ceram. Abs.*, **10** [9], 658 (1931). M.V.K.

Chemistry of Coal. W. FUCHS. *Chem. & Ind.*, **51** [30], 641 (1932); for abstract see *Ceram. Abs.*, **10** [12], 857 (1931). G.R.S.

PATENTS

Kiln furniture. L. L. LADD. U. S. 1,879,808, Sept. 27, 1932.

Smoke-cleaning device. JOSEPH MITCHELL. U. S. 1,881,058, Oct. 4, 1932.

Geology

Laws of soil colloidal behavior. IX. Amphoteric reactions and isoelectric weathering. SANTE MATTSON. *Soil Sci.*, **34** [3], 209–40 (1932).—When an insoluble weak base, represented by $B(OH)_3$, reacts with a weak acid, as H_3A, to form an insoluble compound there results (*a*) $HA\langle^{B(OH)_2}_{B(OH)_2}$, (*b*) HA = BOH, and (*c*) $^{H_2A}\rangle BOH$ or ^{H_2A} any intermediate combination. These compounds contain acid and basic residues of varying strength and react amphoterically. Where the acid residue is weak, as in (*a*), the isoelectric p_H will be high and where the acid residue is strong as in (*c*), the isoelectric point will be at a low p_H. This relation between the composition and the isoelectric p_H has been applied to a study of the process of weathering. It is true in general that amphoteric compounds are least dispersible, least soluble, and least ionized, and are therefore most stable at their isoelectric point. Under conditions of heavy leaching the tendency would be for the formation of an isoelectric soil complex. A study of the prevailing p_H in different latitudes of humid regions, of the composition of soil colloids, and of river water supports this theory of isoelectric weathering. For Part VIII see *Ceram. Abs.*, **11** [8], 469 (1932). G.R.S.

Soluble aluminum studies. I. Concentration of aluminum in the displaced soil solution of naturally acid soils. W. H. PIERRE, G. G. POHLMAN, AND T. C. MCILVAINE. *Soil Sci.*, **34** [2], 145–60 (1932).—Thirty acid soils representing some principal soil types were obtained from nine states, and the relations between their soluble aluminum content and the concentration of hydrogen and other ions and salts in the displaced soil solution were studied. G.R.S.

Studies on the mechanism of ionic exchange in colloidal aluminium silicates. HANS JENNY. *Jour. Phys. Chem.*, **36** [8], 2217–58 (1932).—Ionic exchange (replacement of cations) was studied in various artificial and natural aluminium silicates such as permutite, zeolite, Putnam clay, and bentonite. Electrodialized colloidal aluminium silicates contain exchangeable hydrogen ions and behave in many respects as colloidal acids. The strengths of these acidoids vary as follows: permutite < Putnam clay < bentonite. In all exchange reactions pronounced lyotropic series can be observed. For the adsorption of monovalent cations the following relationships were found: permutite: Li < Na < K < Rb < Cs < H, Putnam clay: Li = Na < K < H, bentonite clay: Na ≦ Li ≦ K < H. The release or outgo of adsorbed cations takes place in the reverse order of the intake. The explanation of the individual behavior of the cations in the exchange process is based on Coulomb's law which expresses the magnitude of attraction existing between negative oxygen ions of the crystal lattice and adsorbed ions. Ionic exchange affects the hydration of the colloidal particle. On the basis of space relationships it is suggested that clays with adsorbed divalent cations should contain more water than clays having monovalent cations. H-systems are necessarily most hydrated. G.R.S.

Mechanism of the coagulation of sols by electrolytes. III. Exchange adsorption during the coagulation of hydrous oxide sols. H. B. WEISER AND G. R. GRAY. *Jour. Phys. Chem.*, **36** [8], 2178–93 (1932).—A comparison was made of the methods employed by Weiser and by Rabinovitsch for following the stepwise displacement of chloride ion from hydrous oxide sols during the dropwise addition of electrolyte to the sol. For Part II see *Ceram. Abs.*, **10** [8], 606 (1931). G.R.S.

New methods and points of view on the synthesis of minerals and rocks. V. M. GOLDSCHMIDT. *Naturwissenschaften*, **20** [20], 337–40 (1932).—In the synthesis of minerals by means approximating the natural processes, the main difficulty encountered is the time factor, *e.g.*, mineral formation in nature often occurs over a period of hundreds of years. To eliminate this time factor (1) materials such as fluxes may be added to hasten mineral reaction and formation; (2) extremely high temperatures may be attained for facilitating crystal formation; or (3) experiments may be performed whereby extremely small crystals can be identified and the process of formation studied in detail. Such means of experimentation are offered by the microscope and X-ray. These methods have been used extensively in the firing of clays, reactions in silicate melts, etc. From the difference in the size of the crystals as produced in the laboratory and those found naturally, a correction may be applied for the time factor. L.T.B.

Secondary structure and mosaic structure of crystals. F. ZWICKY. *Phys. Rev.*, **40** [4], 63–77 (1932); abstracted in *Metals & Alloys*, **3** [8], 239 (1932).—A brief summary is given of some of the essentials of the theory of the secondary structure. This structure is very sensitive to external distributing effects which frequently cause the transition

of crystals from thermally stable into thermally pseudostable configurations for which the term mosaic structure is proposed. A discussion of the relation of the mosaic structure to the secondary structure is given. It is shown that several fundamental causes are operative during the growth of crystals which endanger the formation of thermally stable configurations. The most important of these is due to the fact that on solidification the heat of fusion must be carried away from the growing surface. The resulting temperature gradient is often great enough to produce plastic deformation in the crystals *in statu nascendi*. A short review is given which shows that the adoption of the conception of a secondary structure and the closely related mosaic structure provides an adequate basis for the understanding of the totality of phenomena which is characteristic for the solid state of matter. E.P.R.

Crystal structure of kaolinite. J. W. GRUNER. *Z. Krist.*, **83** [1–2], 75–88 (1932).—The structure of kaolinite was examined by the powder method. Pauling's recent proposal of a monoclinic hemihedral sheet structure for kaolinite was confirmed. The space group is C_s^4. The dimensions of the unit cell are $a_0 = 5.14$Å, $b_0 = 8.90$Å, $c_0 = 14.51$Å, and $\beta = 100°12'$ though β may be as large as $101°30'$. The cell contains four molecules $(OH)_4Al_2Si_2O_5$. The theoretical density is 2.609. Anauxite is kaolinite in which Si occupies Al positions with a covalence of 6. To compensate the electrostatic valence O takes the place of OH, which accounts for a decrease of H_2O in analyses of anauxite. G.R.S.

Different habits of fluorite crystals. JULIEN DRUGMAN. *Mineralog. Mag.*, **23** [137], 137–44 (1932).—A treatise is given on the variations in habit of fluorite crystals. Temperature is suggested as the probable main factor conditioning the habit of fluorite at different stages of growth. A.K.

Kinetics of crystallization processes. F. v. GOLER AND G. SACHS. *Z. Physik*, **77** [5–6], 281–85 (1932).—An equation has been worked out for the kinetics of a definite crystallization process from nuclei formation and crystal growth. Size distribution of particles is discussed. L.T.B.

Why crystals exist. F. ZWICKY. *Metals & Alloys*, **3** [8], 240 (1932); for abstract see *Ceram. Abs.*, **11** [1], 59 (1932). E.P.R.

Percussion and pressure figures and mechanical twinning of quartz. A. SHUBNIKOV AND K. ZINSERLING. *Z. Krist.*, **83** [3–4], 243–64 (1932).—A method was worked out for the preparation of percussion and pressure figures of quartz. The form of the figures agreed with the geometrical crystallography of quartz. Factors which influenced the magnitude of the figures were studied. By means of pressure of a steel sphere on the quartz surface a twin was formed. Its form agrees with the symmetry of quartz. G.R.S.

Anorthoclase-bearing rock glass. L. HAWKES AND H. F. HARWOOD. *Mineralog. Mag.*, **23** [138], 163–74 (1932).—Analyses and description are given of a feldspathic rock which is favorable for this investigation of the relationship of the composition of the first-formed feldspar to that of the ground mass. The rock is high in Na_2O, bearing insets relatively high in K_2O, so that differentiation appears to be proceeding toward a soda-rich magma. This is contrary to a general rule deducted by Vogt that in acid magmas with an orthoclase content of less than 40%, the first-formed feldspar is poorer in orthoclase than the magma. A.K.

Synthesis of kaolin. W. NOLL. *Naturwissenschaften*, **20** [21], 366 (1932).—Kaolin was synthesized from an amorphous $Al_2O_3 \cdot 2SiO_2$ aqueous complex by hydrothermal treatment in a pressure bomb. L.T.B.

Distinction of pyrite from marcasite. F. A. BANNISTER. *Mineralog. Mag.*, **23** [138], 179–87 (1932).—Color and density methods can not be conclusive and chemical methods are not reliable. The application of X-ray methods affords most certain means of distinction between marcasite and pyrite and a detailed account of the methods used is given. A.K.

Some aspects of applied geophysics. A. O. RANKINE. *Nature*, **130** [3281], 421–24 (1932).—The geophysical methods which have proven of practical value in determining underground structure and in locating ore beds are (1) the gravitational method, (2) the seismic method, (3) the magnetic method, and (4) the electrical method. The gravitational method through the use of the torsion balance has given results which have led to the delineation of salt domes, limestone anticlines and synclines, rock faults, and deposits of hematite or of brown coal. The seismic method, employing a seismograph to measure tremors caused by explosions, depends for its success on a large velocity ratio between the rocks constituting the various beds. Salt domes under alluvial deposits fulfill this condition and have been detected by this method. It has also given valuable results in determining the underground contours of limestone anticlines and

deep-seated granitic basements at depths of several thousand feet. Although allowing a greater speed in application than the gravitational method, its results are not as easily interpreted. The magnetic method, consisting of measuring local variations in components of the earth's magnetic field with portable magneto-meters, is the simplest and least costly method to apply. At present, magnetic instruments are not available which will satisfactorily differentiate nonferruginous formations. For a discussion of electrical methods the paper refers to another publication, "The Principles and Practice of Geophysical Prospecting" (*Ceram. Abs.*, **11** [6], 386 (1932)). J.L.G.

Determining clay content of soils by moisture absorption at 70 per cent humidity. A. N. PURI. *Soil Sci.*, **33** [6], 405–11 (1932).—The clay (0.001 mm.) content of a soil can be estimated from moisture absorption between 10 to 70% humidity with a fair amount of accuracy by the help of an empirical formula. G.R.S.

Clay, its origin, classification, and mode of deposition. V. CHARRIN. *Céram. Verrerie*, No. 835, pp. 11–13 (1932).—C. gives the decomposition of rock, chiefly feldspathic, by carbonated waters, temperature changes, etc., as the origin of clay. Suspension in running water and subsequent settling is the usual method of deposition. A classification of clays based on the silica-alumina ratio and impurities is given. A summary of clay production in France is included. M.H.B.

Magnetic surveys over mineral, diabase, and artificial dykes. A. S. EVE AND D. A. KEYS. *Can. Mining Met. Bull.*, No. 239, pp. 119–25 (1932).—Detection of magnetic dykes by using magnetic variometers is the oldest application of geophysics to mining and is one of the more simple and certain methods of locating such deposits. Recent improvements in instruments make it possible to find the dyke, determine with magnetic variometers its strike and dip with fair accuracy, and estimate the approximate depth of overburden when there is no outcrop. Application of electrical methods may be used to distinguish mineral from diabase dykes. Some actual surveys are described. G.M.H.

Chemical and geological problems of kaolin and clay research. E. DITTLER. *Tonind.-Ztg.*, **56** [67], 836–38; [71], 891–93; [75], 939–40 (1932).—The formation of clay and kaolin is discussed. Several factors influence these processes, acting in a different way for alumina, silica, etc. The importance of feldspars, as outlined by different authors, and the action of acids contained in the soil are discussed. The formation of kaolin has taken place mainly in early geological ages and several theories are given for the processes involved. See also *Ceram. Abs.*, **11** [10], 540 (1932). W.M.C.

Diatomite as a high-temperature insulator. ANON. *Metal Ind.* [London], **41** [6], 132 (1932). M.V.K.

Resources of the Mojave Desert. PARK L. TURRILL. *Jour. Chem. Ed.*, **9** [8], 1319–39; [9], 1531–52 (1932).—Detailed descriptions are given of the nonmetallic minerals found in the Mojave Desert basin in southeastern Calif. and southern Nev. It is estimated that 91% of the world's production of boric acid and borax comes from there. Talc and filtering clay are being shipped. Huge deposits of magnesite and alkaline silicates together with "Tremolite," a paper filler, and silica sand for the preparation of a pure form of quartz glass, are being exploited. Diatomaceous earth, kaolin, gypsum, "Bentonite" clays, potter's clays, and asbestos are also found and some of these have reached commercial production. The locality is referred to as "America's Chemical Storehouse." A.K.

Clays and clay-products industry in western Canada. I. G. M. HUTT. *Clay Prod. News*, **5** [5], 4–5 (1932).—H. gives a brief survey of the clay-products industry of western Canada. He defines clay and touches briefly on its formation and the physical and chemical testing of clays from new deposits. **II.** *Ibid.*, **5** [6], 1–3 (1932).—The various known clays of western Canada are classified and described, the locations and uses being given. **III.** *Ibid.*, **5** [7], 1–3 (1932).—The occurrence of various western Canadian clays of commercial importance is described. **IV.** *Ibid.*, **5** [9], 1–3 (1932).—A survey of the clays and clay-products industry of Alberta is presented. See also *Ceram. Abs.*, **11** [8], 467 (1932). W.W.M.

China-clay deposits. ANON. *Clay Prod. News*, **5** [4], 3 (1932).—Opening up of china-clay deposits in the vicinity of Smoky Falls, north of Kyuskasing, will probably continue this year. W.W.M.

Selenium in Canada. EDITORIAL. *Can. Mining Met. Bull.*, No. 242, p. 238 (1932).—Selenium is now produced as a by-product in copper refining by the Ontario Refining Co., Ltd., Copper Cliff, Ontario, and when market conditions improve will probably be recovered at the refinery of Canadian Copper Refiners, Ltd., at Montreal East. See also *Ceram. Abs.*, **11** [11], 590 (1932). G.M.H.

Mineral position of the British Empire. CHARLES CAMSELL. *Can. Mining Met.*

Bull., No. 238, pp. 15–29 (1932).—There is a large Empire surplus of aluminum, chromite, copper, iron, lead, manganese, nickel, tin, tungsten, zinc, asbestos, china clay, coal, fluorspar, graphite, gypsum, mica, nitrates, petroleum, phosphates, and pyrites, an adequate supply of barite and magnesite, an inadequate supply of antimony, and a negligible supply of mercury, potash, sulphur, talc, and soapstone. In Canada there is a large domestic surplus of copper, lead, nickel, zinc, asbestos, gypsum, mica, pyrites, talc, and soapstone, an adequate supply of fluorspar, graphite, and magnesite, an inadequate supply of antimony, barite, and coal, and a negligible supply of aluminum, chromite, iron, manganese, mercury, tin, tungsten, china clay, nitrates, petroleum, phosphates, potash, and sulphur. There is little relation between the Empire's position in regard to mineral resources and its actual mineral trade position, there being some minerals such as copper of which there are large reserves though foreign supplies are depended on in some measure. G.M.H.

Red and yellow lateritic soils of Brazil. V. AGAFONOFF. *Soil Research*, **3** [1], 13 (1932).—Chemical analysis and the microstructure of the soils were studied. It is shown that the red and yellow colors are derived from the basalts from which the soils were formed. Iron oxide and alumina are present in the form of colloids. C.G.H.

Bultfonteinite, a new mineral from South Africa. J. PARRY, A. F. WILLIAMS, AND F. E. WRIGHT. *Mineralog. Mag.*, **23** [138], 145–62 (1932).—Afwillite occurs under similar conditions as those for bultfonteinite and it is possible to express the composition of bultfonteinite in terms of afwillite plus fluorite and calcium hydroxide. A detailed description of bultfonteinite's properties is given. A.K.

German phonolites used in the ceramic and glass industries. HANS MOTSCHMANN. *Sprechsaal*, **65** [34], 619–21; [35], 637–39 (1932).—The chief characteristics and properties of different German phonolites are discussed and analyzed. M.V.K.

Investigations of the Vladimirov clays. P. P. BUDNIKOFF. *Mineral. Suir'e*, **5** [9], 1246–54 (1930); abstracted in *Chem. Zentr.*, **I**, 2102 (1931).—Various clays of the Vladimirov region show slightly different melting points and vitrifying temperatures. They contain up to 37.4% alumina and crack easily during firing. M.V.K.

Clays of the Shchekin region. P. P. BUDNIKOFF. *Mineral. Suir'e*, **5** [9], 1240–45 (1930).—P. discusses the characteristics and properties of the various clays of the Shchekin region. M.V.K.

Refractory clays of the Bolotninski deposits. Y. A. KUZNETZOV. *Mineral. Suir'e*, **5** [9], 1122–35 (1930).—K. discusses various refractory clays of the Bolotninski region. Large deposits of white clays are found. Their SiO_2 content varies between 47 to 60%; the Al_2O_3 content, between 27 to 33%; Fe_2O_3, from 1 to 2%; CaO, about 1%; MgO, from 0.2 to 1.1%. The refractoriness of the pure clays is high; they begin to vitrify at 1730°. The genesis of the clays is given. M.V.K.

Ukrainian quartzites. P. P. BUDNIKOFF. *Mineral. Suir'e*, **5** [9], 1254–59 (1930).—Data on the chemical composition, specific gravity, and microstructure are given. M.V.K.

Comparative data of Russian and foreign kaolins. V. ISKYUL, P. BORODITZKAJA, AND T. KORZUKHINA. *Mineral. Suir'e*, **7** [1], 66–78 (1932).—Kaolins from U.S.S.R., Germany, Czechoslovakia, England, and North Carolina are compared and analyzed. M.V.K.

BOOKS AND BULLETINS

Physical Chemistry in Its Application to Problems of Mineralogy, Petrography, and Geology. (Die Physikalische Chemie in ihrer Anwendung auf Probleme der Mineralogie, Petrographie, und Geologie.) HERMANN JUNG. Gustav Fischer, Jena, 1930. 10 M. *Naturwissenschaften*, **20** [31], 582 (1932).—This small but comprehensive volume includes sections dealing with the following subjects: concept of equilibrium in chemistry, dependence of stability on pressure, effect of pressure on two-component systems, solution and solid solution, ternary systems, systems with volatile components, hydrothermal mineral synthesis, magmatic differentiation, general geochemical observations, and other subjects. J. has treated his topics in an excellent manner. L.T.B.

Geology and Petrology of Surinam (Dutch Guiana). R. IJZERMAN. xvi + 568 pp., maps. Martinus Nijhoff, The Hague, 1931. (In English.) Price 24 gld. Reviewed in *Geographical Jour.*, **80**, 80–81 (1932).—Bauxite, kaolin, psilomelane, as well as gold, etc., are of economic importance. H.H.S.

Microscopical Characteristics of Minerals Composing Rocks. KARL CHUDOBA. *Z. Krist.*, **83** [3–4], 327–28 (1932); for abstract see *Ceram. Abs.*, **11** [10], 540 (1932). G.R.S.

Structure of Crystals. RALPH W. G. WYCKOFF. *Metals & Alloys*, **3** [8], 241 (1932); for abstract see *Ceram. Abs.*, **11** [2], 138 (1932). E.P.R.

Petrography and Petrology. F. F. GROUT. McGraw-Hill Book Co., New York, 1932. 522 pp. $5.00. *Jour. West Soc. Eng.*, **37** [4], 226 (1932). W.W.M.

Pegmatite deposits of Virginia. ANON. Va. Geol. Surv. *Bull.*, No. 33; *Rock Prod.*, **35** [19], 49 (1932).—The report discusses chiefly the mica and feldspar deposits of economic importance in the Piedmont, Va., region. W.W.M.

Chemistry and Physics

Viscosity of liquids. E. N. DA C. ANDRADE. *Nature*, **128** [3237], 835 (1931).—A. agrees with G. W. Stewart (*Nature*, **128**, 727 (1931)) that the liquid state resembles the crystalline more closely than the gaseous. He postulates that liquid viscosity is due to an interchange of momentum between adjacent layers. This is effected by a temporary union of molecules enduring only for the brief time required for the molecule to acquire a common velocity of translation, *i.e.*, a temporary clinging of molecules of two parallel rows moving past each other. This leads to the expression, $\eta = \frac{2mv}{\sigma}$, where η = viscosity, m = mass of molecule, σ = average distance between centers of molecules, and v = frequency of junction or disjunction per second which varies with the temperature. Assuming that a melted solid retains in its liquid form enough of its crystalline character for the molecules to have a frequency of vibration which is practically the same as that of the solid form at the melting point, A. employs Lindeman's formula, $\nu = C\sqrt{\frac{T}{A\ V_A^{2/3}}}$, where T_m = melting point, A = atomic weight, V_A = volume of a gram atom at temperature, T_m, and $C = 2.8 \times 10^{12}$, to give the following equation: $\eta_m = 7.82 \times 10^{-4} \cdot \frac{(A\ T_m)^{1/2}}{V_A^{2/3}}$. Calculated and experimental values are compared for mercury, bromine, iodine, chlorine, oxygen, and hydrogen. Experimental viscosities for many liquid metals were conflicting and were not considered. A. considers the agreement between calculated and experimental values as satisfactory confirmation of his theory that liquids at the melting point behave as crystals which have lost their general rigidity. J.L.G.

Rhythmic crystallization of melts. I. A preliminary investigation of the factors influencing the phenomenon. J. F. J. DIPPY. *Jour. Phys. Chem.*, **36** [8], 2354–61 (1932).—Rhythmic crystallization of thin films of a number of molten substances was observed. Investigations on the effects of supercooling, the presence of an air interface, and the thickness of film were made. G.R.S.

Procedure for the study of finely crystalline powdered materials by means of electron diffraction. F. TRENDELENBURG. *Naturwissenschaften*, **20** [35], 655–56 (1932).—By this method of electron diffraction a characteristic pattern of materials is obtained which is similar to an X-ray diffraction pattern. Sharp patterns are obtained from materials which give indistinct X-ray patterns. L.T.B.

Calculation of the number and distribution of sizes of spherical crystals in opaque substances by means of circles obtained with a plane section. ERICH SCHEIL. *Z. anorg. allgem. Chem.*, **201** [3–4], 259–64 (1931).—Tammann and Crone have shown that conclusions may be drawn regarding the volume of materials from the size and distribution of the visible plane surfaces of the crystals in a section of an opaque material such as a metal. The authors have reached a rigid mathematical solution of the problem with the aid of probability calculations for the case of spherical crystals imbedded in an indifferent medium. L.T.B.

Procedure for changing easily crystallizing materials into a glass. G. TAMMANN AND A. ELBRACHTER. *Z. anorg. allgem. Chem.*, **207** [3], 268–72 (1932).—At a constant temperature the number of spontaneous crystal nuclei in an undercooled liquid may be expressed as follows: $N = n \cdot v \cdot z$, where N = the number of nuclei, v = the volume of liquid, and z = time. If the drops of a liquid are cooled quickly, then the temperature of the smaller drops decreases more rapidly than the temperature of larger drops. The number of nuclei forming, therefore, depends on the size of the drops since the cooling rate is dependent on size. When the drops are small the number containing crystal nuclei is zero. Glass was blown into a fine spray by an air blast and the drops were examined microscopically to determine which had crystallized. The number of drops and their size were noted. The size of the drops below which no crystallization was evident is given for various inorganic and organic salts. L.T.B.

Chemical and physical processes taking place during dehydration and rehydration of kaolin crystals. H. JUNG. *Chem. Erde*, **7**, 113 (1932); *Sprechsaal*, **65** [34], 625 (1932).—J. discusses the latest researches of P. Schachtschabel (*Ceram. Abs.*, **10** [7], 524 (1931)), K. Spangenberg and J. Rhode (*Diss. Kiel*, 1927), and others, and concludes that kaolin can be partly dehydrated without losing its structure. Because the remaining water is uniformly distributed in the crystal, "zeoliteric" dehydration is questioned. With a further dehydration an amorphous product results which is transformed into a crystalline form (α-kaolin, $Al_2Si_2O_7$) when heated to about 550°. The fact that this transformation takes place approximately at the same temperature as the transformation of β-quartz into α-quartz leads to the conclusion that there is a relationship between these phenomena. With rehydration, the process of absorbing water depends on whether the preceding dehydration was partial or complete. In the first case the water can penetrate into the remaining crystal lattice; in the latter, one or several aluminium silicates are formed which can be converted again into kaolin with appropriate treatment.
M.V.K.

Note on the true specific gravity of colloid-containing materials such as the bentonites. R. M. WOODMAN. *Jour. Soc. Chem. Ind.*, **51** [38], 327–28 (1932).—Carbon tetrachloride, benzene, and toluene cause the least swelling of bentonite. Liquids causing the greatest swelling appear to be alcohol, pyridine, and acetone. True specific gravity does not appear to be absolutely related to swelling power or to dispersivity.
G.R.S.

Space lattice constants of α-Fe_2O_3 and γ-Al_2O_3. R. BRILL. *Z. Krist.*, **83** [3–4], 323–25 (1932).—New values are as follows: $\alpha = 5.429$ and $\alpha = 54° 58'$ for α-Fe_2O_3, and $\alpha = 7.91$ for γ-Al_2O_3. G.R.S.

Heat of formation of indium trioxide and germanium trioxide. G. BECKER AND W. A. ROTH. *Z. phys. Chem.*, **A161** [1–2], 69–76 (1932).—The heats of formation of In_2O_3 and GeO_2 were newly determined. The method of determination on incomplete oxidation and volatilization of the oxides is described. L.T.B.

Natural constants of stable zinc oxide. GUSTAV F. HÜTTIG AND KARL TOISCHER. *Z. anorg. allgem. Chem.*, **207** [3], 273–88 (1932).—Some of the constants which are reported include melting point, heat of sublimation, triple point, heat capacity, specific heat, crystal lattice, density, compressibility, and thermal expansion. Stable zinc oxide has a mixed lattice in which uncharged atoms predominate over ions. The size of atomic and ionic radii and the possibility of the existence of different modifications of ZnO are discussed. L.T.B.

Variations in extinction coefficients during the course of jelly formation. S. PRAKASH. *Jour. Phys. Chem.*, **36** [9], 2483–96 (1932).—The variations in extinction coefficients during the process of jelly formation of the following substances were investigated; ferric, chromic, aluminium, and zirconium hydroxides, zirconium molybdates, zirconium borate, and mercuri-sulpho-salicylic acid. G.R.S.

Dielectric constant and power factor of some solid dielectrics at radio frequencies. W. ANDERSON. *Phil. Mag.*, **13**, 986 (1932).—The dielectric constant and power factor of mirror glass and unglazed porcelain were measured at frequencies of 150 and 1500 kc. Data are given for seven organic insulators. The results for glass and porcelain were the same at both frequencies. J.T.L.

Plane-polarized light in the microscopic investigation of ores and metals. FRELEIGH FITZ OSBORNE. *Can. Mining Met. Bull.*, No. 237, pp. 1–13 (1932).—A discussion of methods used in the study of opaque minerals with plane-polarized light is given. Methods of detecting anisotropism, using crossed nicols, are most suitable for ordinary structural determination in ores and metals. Methods requiring test plates may give a quantitative measure of the anisotropism under crossed nicols. The methods of compensation by a glass plate are more accurate than rotating the upper nicol, but their usefulness in the diagnosis of mineral species depends on finding the maximum rotation which makes them complicated for routine work. The vertical illuminators which cut off part of the field of the objectives produce depolarizing effects and the results observed using the more refined methods are less satisfactory than those using a film illuminator. The polarizing type suggested by the author has advantages, especially when precise observations are desired. G.M.H.

Nature of adhesion. J. W. MCBAIN AND W. B. LEE. *Chem. Trade Jour.*, **91** [2362], 188 (1932).—The relation of adhesive power to molecular structure, specific and mechanical adhesion, and adhesives and lubricants are discussed. M.V.K.

Grain size, grain form, and the degree of division of kaolin. II. RUDOLF LORENZ. *Ber. deut. keram. Ges.*, **13** [8], 356–62 (1932).—A comprehensive description is given of various methods of determining the form and shape of kaolin grains, making use of such

equipment as stereomicro-cameras, etc. Illustrated. For Part I see *Ceram. Abs.*, **11** [9], 504 (1932). E.J.V.

Limits belonging to a nonuniform grain distribution. O. STERN. *Tonind.-Ztg.*, **56** [66], 825–28 (1932).—The laws of A. Abrams and J. Bolomey are extended and new equations are given. W.M.C.

New (colorimetric) method for the determination of lead. N. L. ALLPORT AND G. H. SKRIMSHIRE. *Analyst*, **57**, 440–49 (1932).—To the Pb as $PbSO_4$ are added citric acid, ammonia, and KCN. The cooled solution is extracted with 0.1% solution of diphenylthiocarbazone in chloroform. Na_2S solution is added to the extract after further treatment, and the color is matched against a standard Pb solution. Bi interferes. H.H.S.

Determining arsenic, antimony, tin, and zinc in minerals and alloys by titration with potassium iodate. I. I. LURIE. *Mineral. Suir'e*, **6** [7], 731–42 (1931); *Chim. & ind.*, **27** [4], 1080 (1932).—L. studied the application of Jamieson's titrimetric method of potassium iodate for determining arsenic, antimony, tin, and zinc in minerals and alloys. The titration is made in the presence of chloroform which is colored by iodine liberated during reaction. The disappearance of the coloration of the chloroform layer shows the end of the titration. The experiments showed that this method is suitable for determining antimony and arsenic and gives excellent results. Tin, however, must be reduced into stannous chloride and titrated in a current of CO_2 or with iodate. For determining zinc, this method gives good results in the absence of iron. Zinc is precipitated in the form of double sulphocyanide of zinc and mercury and then titrated with iodate. In the presence of iron, L. suggests the following method: 1 g. of tartaric acid and several drops of a potassium sulphocyanide solution are added to the acid solution containing zinc and iron. The liquid becomes red. A concentrated solution of sodium carbonate is carefully added till the color changes to lemon yellow, 15 to 20 cc. of mercuric chloride and potassium sulphocyanide are added, and the mixture is shaken. A white precipitate of double sulphocyanide of zinc and mercury is formed. The solution is left to rest, filtered, and washed with cold water. The determination is made gravimetrically or by titration. M.V.K.

Volumetric determination of silica in the presence of compounds of aluminum and iron. V. TARTAKOVSKII. *Mineral. Suir'e*, **6** [12], 1075–87 (1931).—The method is based on the transformation of silicates into fluosilicates by treatment with HF and NaOH and the titration of the resulting Na_2SiF_6 (K_2SiF_6) in hot solution with 0.5 normal NaOH and phenolphthalein. (1) A sample of a silicate of quartz containing 0.02 to 0.2 g. of SiO_2 is mixed with 10 to 20 cc. of 2 normal NaOH and 5 to 6 cc. of HF and evaporated to dryness on the water bath. To decompose any $NaHF_2$ formed, 1 g. of HCO_2Na for every 5 cc. of NaOH used is added, the solution is evaporated, and the residue is dried at 120 or 130° (whereby the free HCO_2H escapes) and titrated. NaF and the excess of HCO_2Na in the residue do not affect the titration of Na_2SiF_6. Alkalis, alkaline earth metals, and Pb in silicates do not impair the results of analysis. (2) If analyzed silicates contain metals other than alkalis, their insoluble hydroxides formed by the treatment with NaOH will be contained in the precipitate of Na_2SiF_6 and titrated with NaOH. In this case Na_2SiF_6 (K_2SiF_6) is separated from the residue by heating it with HF and by adding first solid KCl to a concentration of 20% and then aqueous 20% KCl, filtering, washing the precipitate with aqueous 20% KCl, and titrating with NaOH. These two methods can not be applied in the presence of salts of Al and Fe, because by method (1) Al and Fe are precipitated by the treatment with NaOH and will undergo titration together with Na_2SiF_6, while by method (2) AlF_3 and FeF_3 combine with NaF to form compounds of the cryolite type which are titrated by NaOH and, being insoluble in HF solution of KCl, can not be separated from Na_2SiF_6 and K_2SiF_6. By adding 3 or 4 g. of neutral NaF to 80 or 100 cc. of the solution, the action of NaOH on the compounds of AlF_3 and FeF_3 is checked, and thus the titration of hot solutions of Na_2SiF_6 with NaOH and phenolphthalein is possible. By method (1) silicates containing Th can be analyzed, and by method (2) those containing Ce, Ta, Zr, W, and Ti can also be analyzed. M.V.K.

Volumetric determination of sulphates free from water. N. A. TANANAEV. *Zhur. Khim. Prom.*, **8**, 939–49 (1931); abstracted in *Glastech. Ber.*, **10** [8], 444 (1932).—The determination of SO_4 through precipitating with a known lead nitrate and titrating back the surplus with a soda solution (indicator phenolphthalein) is discussed. M.V.K.

Use of manganese sulphate in the determination of antimony by Low's method. W. G. LEEMANN. *Jour. Soc. Chem. Ind.*, **51** [34], 284 (1932).—A modification of Low's method for the determination of antimony is given in detail. G.R.S.

Caustic soda from sodium fluoride. A. WAGNER. *Chem. Trade Jour.*, 90 [2350], 543–44 (1932).—M. describes the earlier method of Kessler and the method of Buechner known as the "Kiflu" process, the fundamental operation of which consists in the decomposition of sodium fluoride with calcium hydroxide to produce caustic soda and calcium fluoride. M.V.K.

Structure of hemimorphite ($H_2Zn_2SiO_5$). T. IOT AND J. WEST. *Z. Krist.*, 83 [1–2], 1–8 (1932).—The structure was determined by a qualitative X-ray analysis of the crystal using rotation photographs (Cu K_α radiation) and the ionization spectrometer (Rh K_α radiation). The space group is C_{2v}^2 and the unit cell has dimensions a = 8.38Å, b = 10.70Å, and C = 5.11Å. The structure is characterized by the presence of Si_2O_7 groups arranged throughout the crystal with the same orientation. These groups are held together by zinc atoms in such a way that each Zn atom is surrounded by 3 oxygen atoms and one OH group (representing one-half of the water content of the crystal) arranged tetrahedrally. Each OH group is shared by two zinc atoms while each oxygen atom is linked to two zinc atoms and one silica atom. The remaining half of the water present in the crystal state exists simply as water molecules. G.R.S.

Experiment in thermal analysis of talc-carbonate rock. N. V. ANDREEV. *Mineral. Suir'e*, 6 [8–9], 822–28 (1931).—Talc rock undergoes endothermic changes at 300 to 400°, 635 to 665°, and 1000°. In the interval of 600 to 800° the thermal process is more energetic because of the decomposition of $MgCO_3$ and liberation of CO_2. At 900 to 1000° the endothermic effect is caused by the decomposition of talc and the setting free of water. At about 900°, the endothermic effect is produced by the oxidation of FeO to Fe_2O_3. These reactions explain the cracking of brick and plates of talc carbonate rock when fired. The firing process must be done carefully and be brought up to above 1000°. See also *Ceram. Abs.*, 11 [4], 249 (1932). M.V.K.

Ceramic properties of some Ural talcs of industrial importance. L. V. OMINA AND F. M. SYNYAKOV. *Mineral. Suir'e*, 6 [8–9], 828–49 (1931).—The Ural talcs contain more iron and alumina than some foreign products. The melting temperature of unpowdered talcs is about 1525°, while powdered talcs melt at lower temperatures. Freeing talc from ore and metallic iron affects the melting point very little. All grades of talc show a sharp change in the loss on heating between 800 and 1000° because of dehydration and possibly some molecular regrouping of particles with the formation of clinoenstatite. Most talcs on heating at 1300 to 1430° become more hygroscopic and less mechanically cohesive indicating some change in the molecular structure. At 800 to 1000°, all talcs suddenly change their color from gray to yellow and brown. The hardness of talcs fired at 1300 to 1430° is sharply reduced. The curves of densities show 2 sharp breaks, at 800 to 1000° and at 1300 to 1380°. It is assumed that talcs calcined at 800 to 1000° and from 1300 to 1430° undergo structural changes. M.V.K.

The system, CaO–Fe_2O_3–SiO_2, in the light of its significance for metallurgical slags. G. SITZ. *Metall Erz*, 29 [11], 209–16; [12], 245–50; [13], 269–76; [14], 298–303; [15], 318–23; [16], 339–46 (1932).—This article includes (1) a review of the literature, (2) experiments with mixtures of the oxides in air, (3) a description of the methods and apparatus, (4) interpretation of the heating and cooling curves, (5) examination of the cooled materials and their magnetic properties, (6) analytical studies of the melts, (7) melting of mixtures of the oxides in a reducing atmosphere, and (8) melting mixtures of the oxides with the addition of ZnO. L.T.B.

The ternary systems, ZrO_2–ThO_2–CaO, ZrO_2–ThO_2–MgO, ZrO_2–BeO–CaO, and ZrO_2–BeO–CeO_2. OTTO RUFF, FRITZ EBERT, AND WILHELM LOERPABEL. *Z. anorg. allgem. Chem.*, 207 [3], 308–12 (1932).—Mixtures of oxides in these systems were heated in the oxyhydrogen flame and the melts were studied with X-rays. The temperatures at which melting begins are given for mixtures containing up to 50% ZrO_2. L.T.B.

Effect of SiO_2 on the dissociation of Fe_2O_3. J. KLEFFNER AND E. J. KOHLMEYER. *Metall Erz*, 29 [10], 189–94 (1932).—Studies on the dissociation of pure Fe_2O_3 are reviewed. The effect of additions of SiO_2 was studied up to temperatures of 1600°C. The experiments were carried out in nitrogen and in air. The presence of silica did not affect the dissociation. The melting point of ferrosoferric oxide was determined as 1580°C in nitrogen. L.T.B.

Selection of raw materials for manufacturing soluble glass. E. S. KRONMAN. *Mineral. Suir'e*, 6 [7], 742–44 (1931); abstracted in *Chim. & ind.*, 27 [6], 1353 (1932).—The alumina, lime, magnesia, and iron contents determine whether a material can be used for soluble glass. Sand and sulphate usable for the manufacture of ordinary glass may not be adapted for the production of soluble glass. M.V.K.

Gas as fuel for pottery firing. STOKE-ON-TRENT GAS DEPARTMENT. *Fuel Econ.*, 7

[84], 523–27 (1932).—At the potteries of A. G. Hackney & Co. of Fairfield Pottery, Hanley, in a gas-fired kiln with a working chamber 10 x 4 x 4 ft. and with two regenerative chambers under the hearth, single-fired glazed porcelain is fired in an oxidizing atmosphere without the use of saggers. The ware is heated uniformly and is not discolored. The cost of fuel has been reduced from 7½% of the selling price of the articles when coal was burned and the ware set in saggers to between 4½ and 5% of the selling price when gas is burned. W.E.R.

Combustion processes in flames. ANON. *Mech. World*, **92** [2383], 221 (1932).—The reactions occurring in burning gases consist of the breaking down of complex hydrocarbons and the combustion of the simpler molecules so formed. The two series of reactions are not independent, and their mutual interaction is evidenced in the velocities of ignition of mixtures of gas and air which are not proportional to the quantities of gas and air present. Similarly, the ignition velocities of mixtures of combustible gases do not follow the law of mixtures. The ignition velocities of a series of mixtures of gases and vapors with various proportions of air have been determined and plotted as curves against the composition of the mixture. These curves indicate that the ignition velocity attains a maximum value for a certain mixture which, however, does not correspond to the theoretical ratio of gas to air for complete combustion but contains an excess of gas. Similar determinations have also been made with mixtures of the same substances with CO in various proportions. The curves obtained indicate that the maximum velocity is not proportional to the composition of the mixture and that the highest velocity of ignition is not obtained by combining two mixtures of gas and air having the maximum ignition velocity. E.P.R.

BOOKS

Introduction to Microphotography with Simple Instructions. (Anleitung zur Mikrophotographie auch mit einfachen Einrichtung.) LUDWIG HEINE AND FRITZ SKELL. Gustav Fischer, Jena, 1931. 5.50M. *Naturwissenschaften*, **20** [5], 96 (1932).—Microphotographic technique is described simply in detail. L.T.B.

Chemical Calculations. J. S. LONG AND H. V. ANDERSON. *Chem. & Ind.*, **51** [34], 709 (1932); for review see *Ceram. Abs.*, **11** [11], 597 (1932). G.R.S.

Sorption of Gases and Vapors by Solids. J. W. MCBAIN. 25s net. *Chem. Trade Jour.*, **90** [2351], 569 (1932); for abstract see *Ceram. Abs.*, **11** [4], 281 (1932). M.V.K.

Physics of Solids and Fluids. P. P. EWALD, T. PÖSCHL, AND L. PRANDTL. *Metals & Alloys*, **3** [6], 166 (1932); for abstract see *Ceram. Abs.*, **11** [1], 63 (1932). E.P.R.

Electrochemistry. C. J. BROCKMAN. *Metals & Alloys*, **3** [6], 170 (1932); for abstract see *Ceram. Abs.*, **11** [6], 385 (1932). E.P.R.

Glazes, Enamels, Ceramic Colors, and Masses. E. I. ORLOV. *Jour. Soc. Glass Tech.*, **16** [62], 289 (1932); for review see *Ceram. Abs.*, **11** [1], 64 (1932). G.R.S.

PATENT

Process and apparatus for the production of zinc white. E. FEUER AND P. KEMP. Brit. 379,855, Sept. 14, 1932.

General

Simplified method for the accurate wet blending of glazes and slips. KARL M. KAUTZ. *Jour. Amer. Ceram. Soc.*, **15** [11], 644–46 (1932).

Influence of Portland cement on the physical properties of clay. A. V. FILOSSOFOV. *Zhur. Prikladnoĭ Khim.*, **4** [6], 773–76 (1931); abstracted in *Chim. & ind.*, **27** [6], 1349 (1932).—Clay can be made resistant to water by (1) treating it with chemicals which produce compounds able to cement clay particles and preserve them from disaggregation by water, and (2) incorporating materials binding the clay particles and forming a mechanical skeleton which protects them from water. F. used Portland cement and found that an addition of 5 to 10% Portland cement to clay diminishes the shrinkage of the clay on drying. It renders the clay able to withstand water. It does not prevent it from swelling, however, which is accompanied by an increase in water, diminishing the cohesion between clay particles. M.V.K.

Refractoriness. H. A. WHITE. *Jour. Chem. Met. Mining Soc. S. Africa*, **32** [6], 97–101 (1931); discussion in *ibid.*, **32** [7], 122–27; [12], 333–34 (1932).—In many branches of metallurgy some otherwise available ores are spoken of as refractory, meaning that they are less than usually amenable to the known processes of extraction. The

object of this paper is to provide a measure of refractoriness which shall be applicable to most cases, but more particularly to the various banket ores of the Witwatersrand. Formulas are developed based on fineness of grinding, time of grinding, refractoriness, and value of ore. W.E.R.

Flotation of kaolin, a contribution for the flotation of oxides. OSKAR SOMMER. *Metall Erz*, **29** [13], 268–69 (1932).—S. discusses the meaning of coagulation, the type of peptization, direct and indirect flotation, and the "discharge" of quartz by means of a hydrophilic layer of SiO_2 gel. Experiments were performed in which water glass, $AlCl_3$, and soap were used for separating the kaolin. L.T.B.

Sedimentation of clays. E. W. KANNING, R. J. HARTMAN, AND F. CHILDS. *Jour. Phys. Chem.*, **36** [9], 2369–82 (1932).—The data obtained permit the determination of particle size, the per cent settled out at different time intervals, and the per cent of a definite range of particle size existing in each sample. The sedimentation curves are graphic representation of the data. The rate of settling of particles from aqueous suspension depends on two factors, specific gravity and the size of the particles. The generalizations pointed out may be applied to any aqueous clay suspension. G.R.S.

Practical clayworking. ANON. *Brit. Clayworker*, **41** [485], 186–88 (1932).—Numerous clay varieties (English) and their characteristics are described. The preparation of the clay, weathering, soaking, souring, and resting (storage), washing clay and chalk, and the modern mixer-feeder are discussed. See also *Ceram. Abs.*, **11** [11], 593 (1932). R.A.H.

Fundamentals and economies in the clay industries. XX. ELLIS LOVEJOY. *Clay-Worker*, **98** [3], 100–102 (1932).—A theoretical explanation of drying is given with a discussion of shrinkage. Stress is laid on the differential flow of shrinkage water as a means of explaining progressive shrinkage, since L. believes that it is a factor in safe drying and that it will explain many inconsistencies in drying behavior. For Part XIX see *Ceram. Abs.*, **11** [11], 570 (1932). E.J.V.

Utilizing the residual ashes of the Wurtemberg oil shales. F. WACLAW. *Tonind.-Ztg.*, **56** [57], 718–20; [59], 765–66 (1932); discussion in *ibid.*, **56** [65], 816 (1932).—The Wurtemberg oil shales are being used for heating and for oil extracting. Brick are made from the ashes. The manufacture of porous concentrate proved to be uneconomical. The ashes, however, show good hydraulic properties and are being used with lime and cement. W.M.C.

Kieselguhr and its use as a heat insulator. VICTOR CHARRIN. *Génie civil*, **99** [10], 242–44 (1932); abstracted in *Chim. & ind.*, **27** [2], 344 (1932). M.V.K.

Steam utilization for economy. ANON. *Power Plant Eng.*, **36** [16], 628–29 (1932).—Saving by utilizing steam for power development is described. A comparison with purchasing current for motors is made. E.P.R.

Nonmetals head list in HCl resistance. S. L. TYLER. *Chem. Met. Eng.*, **39** [9], 488–89 (1932).—There are only a few materials in general use including stone, chemical stoneware, fused silica, rubber, glass, glass-enameled steel, and carbon refractories for strong acid; wood for weaker acid. Of the totally or almost totally resistant materials, fused silica, glass, glass-enameled steel, chemical stoneware, rubber, tantalum, and the alloy, Hastelloy A, may be mentioned. G.R.S.

Study of the structure and homogeneity of ceramic bodies. PIERRE BREMOND. *Chim. & ind.* [Special No.], pp. 504–506 (March, 1932).—Ceramic products can show different structures, any of which may be either amorphous or crystalline: (1) porous (the pores or voids communicate directly with the outside), (2) alveolar (the voids or bubbles do not communicate with the outside), (3) porous-alveolar (combination of (1) and (2)), and (4) homogeneous (no pores or alveolas). These structures show the apparent and true densities and the apparent and true volumes. A number of formulas relating to these various properties are given and their application to the study of ceramic bodies is discussed. Conclusions show that all ceramic materials are far from having a homogeneous structure. The increase of the temperature during firing produces a progressive closing of pores (vitrification) but at the same time forms microscopic alveolas. The measurements of the heterogeneity of ceramic materials (porosity during firing and formation of alveolas after vitrification) constitute means for exact control of the composition, manufacture, and use of ceramic materials. M.V.K.

Argument against exclusive devotion to scientific and technical knowledge. EDITORIAL. *Bull. Amer. Ceram. Soc.*, **11** [10], 233–36 (1932).

National Research Laboratories. EDITORIAL. *Can. Mining Met. Bull.*, No. 245, p. 156 (1932).—The National Research Laboratories opened at Ottawa were erected by the Canadian Government at a cost of about three million dollars. Two of the principal laboratories are the heavy testing and the electrical laboratories. G.M.H.

Some suggestions to the brick manufacturer. G. MEREDITH MUSICK. *Brick Clay Rec.*, **81** [3], 97–98 (1932).—M., an architect, wants a central experimental plant for research work, more data on cement and lime mortars, and a greater development of American architecture. Illustrated. E.J.V.

Potential value in industry of discoveries which are of comparatively small scientific importance. HARRY MOORE. *Jour. Sci. Instruments*, **9** [9], 273–76 (1932).—M. states that discoveries of small scientific interest are frequently valuable in industry. Examples are discussed. J.L.G.

Recent developments in a chemical age. ALFRED L. FERGUSON. *Jour. Chem. Ed.*, **9** [7], 1181–1201 (1932).—F. emphasizes some of the fundamental deep-seated factors which have caused this to be "the age of chemistry" and indicates sources from which more detailed information may be obtained. It is pointed out that the progress in chemistry has resulted from the development of a research consciousness by those in charge of industrial work. A.K.

Effect of security fraud-prevention laws on mining finance. A. W. ROGERS. *Can. Mining Met. Bull.*, No. 243, pp. 386–92 (1932).—The Security Frauds Prevention Act is now in force in every province of Canada except New Brunswick. It has the following features: (1) It permits sifting out promoters and salesmen with bad reputations. (2) It permits examination of the actions of promoters and salesmen and of the financing of companies formed at their behest. (3) It brings to the attention of the public and the courts all doubtful transactions. (4) It is elastic and it can be molded as experience demands. Several examples of its workings are given. G.M.H.

Training the mining engineer. W. G. MCBRIDE. *Can. Mining Met. Bull.*, No. 238, pp. 30–38 (1932).—This paper for the guidance of teachers, mine managements, etc., outlines the way in which student engineers should be handled. G.M.H.

Taking the pressure out of depression. CHARLES W. HARDY. *Metal Ind.* [New York], **30** [4], 155–56 (1932).—Lower direct labor wages, paying labor on a piecework basis instead of on a time basis, lower indirect labor wages, layoffs and part-time work, lower rent, saving on compensation insurance, operating hours, decreased spoilage, purchasing savings, savings in packing, shipping, power, heat, and light are all briefly considered in making ends meet in the factory. J.L.G.

BOOKS AND BULLETINS

Chemical Encyclopedia: A Digest of Chemistry and Its Industrial Application. C. T. KINGZETT. Balliere, Tindall, and Cox, London, 1932. 1014 pp. 40s net. Reviewed in *Chem. Trade Jour.*, **90** [2353], 620 (1932); *Can. Chem. Met.*, **16** [9], 35 (1932).—The encyclopedia covers all (except the most abstruse) chemical compounds and elements, all natural products of special interest to the chemical industry, and materials marketed under trade and proprietary names. In each case the value of the information given is supplemented by useful and up-to-date bibliographical references. M.V.K.

General Industrial Chemistry. I. Lime and Cement and Glass. II. Ceramics. (Chimie industrielle generale. I. Chauz et Ciments, verrerie, glacerie—gobeletterie.) A. R. MATTHIS. Université du Travail, Charleroi. 30 F per vol. Reviewed in *Chim. & ind.*, **27** [6], 1499 (1932).—The first volume consists of lectures read at the University of Charleroi (Belgium) while the second is composed of lectures read at a technical school in Belgium and deals with refractories, ceramics, enameling, and abrasives. M.V.K.

Pulverized Fuel Firing. S. H. NORTH. *Metallurgia*, **6** [34], 118 (1932); for abstract see *Ceram. Abs.*, **11** [11], 589 (1932). M.V.K.

Flotation. A. M. GAUDIN. Reviewed in *Chem. & Ind.*, **51** [39], 801 (1932); see also *Ceram. Abs.*, **11** [7], 433 (1932). G.R.S.

Shaft-sinking practices and costs. E. D. GARDNER AND J. F. JOHNSON. Bur. Mines *Bull.*, No. 357. 110 pp. Price 15¢ from Supt. of Documents, Govt. Printing Office, Washington, D. C. This report discusses the best methods of performing all phases of shaft sinking. R.A.H.

Geophysical Abstracts. XL. F. W. LEE. Bur. Mines *Information Circ.*, No. 6655. 36 pp. (Free.) For Part XXXIX see *Ceram. Abs.*, **11** [11], 593 (1932). R.A.H.

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Week of February 12

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CERAMIC ABSTRACTS

Compiled by

The American Ceramic Society

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VOLUME 11, 1932

Editorial and Advertising Offices: 2525 North High Street, Columbus, Ohio.
Publication Office: 20th and Northampton Sts., Easton, Pa.

Abstracters: A. Ally, C. R. Amberg, J. B. Austin, A. A. Ayars, R. Barta, M. H. Berns, W. W. Braun, L. T. Brownmiller, E. C. Clemens, W. M. Cohn, P. E. Cox, R. H. Ewell, J. L. Gallup, C. G. Harman, R. A. Heindl, E. B. Hewitt, G. M. Hutt, H. Insley, S. Kondo, M. V. Kondoidy, A. Kuechler, W. Lerch, J. T. Littleton, W. W. Meyer, R. G. Mills, S. I. Perkal, J. G. Phillips, E. P. Rexford, W. E. Rice, D. E. Sharp, G. R. Shelton, H. H. Stephenson, J. G. Tolpin, E. J. Vachuska, H. F. Vieweg, M. J. G. Westfeldt, A. E. R. Westman.

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of the

AMERICAN CERAMIC SOCIETY

A Monthly Publication Devoted to Proceedings of the Society, Discussions of Plant Problems, Discussions of Technical, Scientific, and Art Questions, and Promotion of Coöperative Research

Edited by the Secretary of the Society Assisted by Officers of the Industrial Divisions

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Vol. 11 **December, 1932** **No. 12**

EDITORIAL

TRADE AND TECHNICAL ASSOCIATION ACTIVITIES

By Emerson P. Poste[1]

Upon assuming the responsibilities of administering the affairs of the American Ceramic Society the present Officers and Trustees addressed themselves to a two-fold program. The major responsibility was to conduct the business of the organization so as to operate within the reduced income incidental to the economic situation. The second was to make a study of the affairs of the Society looking to possible improvements of organization and a reëvaluation of responsibilities that might pave the way to greater usefulness in the better days that are to come.

The first objective has been realized thus far and it is assured that the year will close with a surplus figure more favorable than that of December 31, 1931. These ends are being accomplished by a fine coöperation between the Board, Staff, and Publications Committee. There is reason to feel that the necessity for economy and thoughtful analysis has resulted in higher efficiency and quality of service rendered to the membership.

Possible improvements in organization which are under consideration,

[1] President, American Ceramic Society, 1932–33.

some of them now receiving the careful study of the Committee on Rules, will be presented in due time through other channels.

Problems having to do with the functions of the SOCIETY and its relation to other organizations have received much attention, not only by those officially responsible for administration but also by many other members whose suggestions and criticisms have been of much value. It is to these that we now turn.

The complexity of interests represented by the membership as a whole renders it no easy task to determine satisfactorily the proper course to follow with respect to our internal problems, to say nothing of our relation to other agencies. Many of our members are, by vocation, chiefly interested in theoretical or academic matters while, at the other extreme, are those whose work is of the strictly practical type. Between are all classes of individuals, including those whose duties are administrative and therefore must have to do with both of the other points of view. Again, some of the Divisions are constituted, in the main, of technical men and the activities are of a definitely scientific nature. Other Divisions have made a positive effort to gain the interest and support of plant men and to plan their affairs so as to offer corresponding values.

Our Constitution states the purpose of the SOCIETY as follows:

> The object of the SOCIETY is to advance the ceramic arts and sciences by meetings for the reading and discussion of papers, the publication of scientific literature, and other activities.

The spread of opinion which admittedly exists lies in the different interpretations of the term "other activities." It is with this problem that we wish to deliberate.

Various statements have appeared in print in the past, probably the most formal and concise being that by the late General Orton in his Presidential Address (April, 1931, *Bulletin of the American Ceramic Society*).

The extreme positions are (*a*) that ours is a purely technical organization and as such should confine its activities to matters directly or indirectly of a technical nature; (*b*) that our responsibility is to the ceramic industries as a whole and that we should stand ready to promote, and possibly to take the initiative in promoting, a large variety of non-technical activities that may be of benefit to the constituent industries in a broad sense. Between these extremes are all shades of variation.

The majority of branches of the ceramic industries have trade associations organized to carry out the functions properly falling to such bodies. The problem largely reduces itself to the question as to where the functions of the trade associations leave off and where those of the AMERICAN CERAMIC SOCIETY begin, or to what extent they overlap. The purpose of this editorial is to bring to the front various phases of this situation in

hope that they may be clarified or that thought may be stimulated to that end.

That something is lacking in the present status of the matter is evidenced in several ways. In some lines ceramic products are suffering at the hands of competitive products through lack of knowledge on the part of those making decisions as to materials. Certain lines of American-made products are feeling foreign competition because American users are not aware of the merits of domestic goods. There is a great lack of coördination of research and development on the part of manufacturers, institutional, and governmental laboratories, resulting in much duplication of effort and a lack of efficiency within the industries involved. The ceramic educational program at large is suffering from the lack of proper understanding and coördination between the scientific and industrial requirements. Possibly the outstanding evidence of failure on the part of the ceramic industries to meet an opportunity is in the repeated downfall of plans for adequate representation at the coming Century of Progress. It is granted that financial factors bear on this situation; nevertheless, it is quite evident that other branches of industry are making reasonable use of this opportunity to impress on the public the merits of their wares.

Thus we arrive at the query as to how far the AMERICAN CERAMIC SOCIETY should go as a coördinating agency along lines of research, education, product promotion, and the like. It is fitting that this be given particular attention at this time as a guide to future activities and expansion that may be possible when funds become available.

Following specific steps on the part of certain individuals and various approaches to the SOCIETY on the matter of Ceramic Ware Promotion, the Executive Committee carefully considered proposed resolutions which were endorsed and submitted to the Trustees as a whole, receiving their unanimous approval. These resolutions are a matter of record[1] and constitute the only official pronouncement which has been made on the subject. The Board and certain Committees are studying other phases of the problem and may have suggestions or reports to make later in the year.

That there may be a definite basis for further study the following tabulation is submitted as indicating possible relations between trade and technical organization activities with respect to several functions relating to ceramics in general. It is not claimed that the compilation is complete nor accurate in every detail. However, it is the result of careful thought and is offered in the hope that others will make constructive use of it. The officers of the SOCIETY will greatly appreciate any modifications or criticisms that may be made. The only way in which the SOCIETY may be guided by the wisdom of the membership at large is in coöperation

[1] *Bull. Amer. Ceram. Soc.*, 9 [11], 254 (1931).

through response to requests for suggestions, or, better still, helpful ideas submitted on the initiative of individual members. Interest manifest in this way is greatly appreciated.

Trade Association Activities	Technical Society Activities	
Sales	Product Promotion	Publications
Distribution	Management	Literature Review
Transportation	Production	Education
Traffic	Production Costs	Research Promotion
Tariff	Engineering	Fundamental Research
Finance	Process Control	Pure Science and Art
Labor	Process Development	
	Specifications	
	Product Testing	
	Quality of Product	
	Standardization	
	Product Development	
	Applied Research	

ACTIVITIES OF THE SOCIETY

GENERAL PROGRAM, THIRTY-FIFTH ANNUAL MEETING, AMERICAN CERAMIC SOCIETY, HOTEL WILLIAM PENN, PITTSBURGH, PA.

February 12–18, 1933

All meetings will be held in the William Penn Hotel. Admission to technical sessions and manufacturing establishments will be by official badge or student courtesy card only. Tickets for social events will be provided for all who register. The registration fee is $2.00 per person. The hotel charge is $1.00 per person for luncheons.

Sunday, February 12

8:00 P.M. Musicale. Cardinal Room. Admission by ticket only.
10:00 P.M. Reception. Silver Room.

Monday, February 13

9:00 A.M.–8:00 P.M. Exhibits. Ballroom and Urban Room.
10:00 A.M. General Meeting. Cardinal Room.
12:00 M. General luncheon. Silver Room.
2:00 P.M. Meetings of Divisions.
9:30 P.M. Cabaret, dance, and supper. Chatterbox. Admission by ticket only.

Tuesday, February 14

9:00 A.M.–6:00 P.M. Exhibits. Ballroom and Urban Room.
9:30 A.M. Meetings of Divisions.
12:00 M. Luncheons of separate Divisions.
2:00 P.M. Meetings of Divisions.
8:00 P.M. Public lecture. Auspices of Fellows. Assembly Room, lower lobby.

Wednesday, February 15

9:00 A.M.–6:00 P.M. Exhibits. Ballroom and Urban Room.
9:30 A.M. Meetings of Divisions.
12:00 M. Luncheons of separate Divisions.
2:00 P.M. Sight-seeing tour of Pittsburgh (2:00 P.M. Meeting of the Fellows. Cardinal Room).
8:00 P.M. Dr. Phillips Thomas' lecture with demonstrations on "Electrons at Work and Play." Assembly Room, lower lobby. Admission by ticket only.

Thursday, February 16

9:00 A.M.–9:00 P.M. Exhibits. Ballroom and Urban Room.
10:00 A.M. General Session. Business Meeting. Cardinal Room.
12:00 M. General luncheon. Blue Room.
2:00 P.M. Symposium on Business Management. Cardinal Room.

Friday, February 17

ALL DAY. Plant Visits.

LADIES' PROGRAM

Unless otherwise specified all meetings are held in the William Penn Hotel. Tickets will be provided for luncheons, sight-seeing tour, and evening events, except public lecture. Obtain these at registration desk when you register. Admission to technical sessions and manufacturing plants by official badge only. Registration fee $2 per person.

Sunday, February 12

8:00 P.M. Musicale. Cardinal Room. Admission by ticket only.
10:00 P.M. Reception. Silver Room.

Monday, February 13

9:00 A.M.–8:00 P.M. Exhibits. Ballroom and Urban Room.
1:00 P.M. Luncheon. College Club, 143 N. Craig St. Admission by ticket only.

2:30 P.M. Showing of colored motion pictures of Dr. Alexander Silverman's glass collection. 302 Thaw Hall, University of Pittsburgh, University Place and O'Hara St. The collection itself will be on exhibition after the pictures are shown.

9:30 P.M. Cabaret, dance, and supper. Chatterbox. Admission by ticket only.

Tuesday, February 14

9:00 A.M.–6:00 P.M. Exhibits. Ballroom and Urban Room.

11:00 A.M. Tour through Mellon Institute of Industrial Research, O'Hara and Thackeray Sts.

1:00 P.M. Bridge luncheon, Mellon Institute of Industrial Research. Admission by ticket only.

8:00 P.M. Public lecture.

Wednesday, February 15

9:00 A.M.–6:00 P.M. Exhibits. Ballroom and Urban Room.

10:00 A.M. Tour of H. J. Heinz Company's food preserving plant, 1062 Progress St., North Side, followed by luncheon.

1:30 P.M. Sight-seeing tour of Pittsburgh. Cars will leave H. J. Heinz plant immediately after the luncheon. Tickets required.

8:00 P.M. Dr. Phillips Thomas' lecture with demonstrations on "Electrons at Work and Play." Assembly Room, lower lobby. Admission by ticket only.

Thursday, February 16

9:00 A.M.–9:00 P.M. Exhibits. Ballroom and Urban Room.

10:00 A.M. Tour through Carnegie Museum and Phipps Floral Conservatory, Schenley Park.

1:00 P.M. Luncheon. Ruskin Apartments, 120 Ruskin Ave. Admission by ticket only.

Friday, February 17

ALL DAY. Plant Visits. Women who are interested may arrange to accompany the men on these trips.

PROPOSED REVISION OF THE CONSTITUTION AND BY-LAWS OF THE AMERICAN CERAMIC SOCIETY[1]

Article II. Section (3)

Change to read as follows:

Honorary Members shall be nominated by at least ten Active Members and unanimously approved by the Board of Trustees. Such nominations shall be placed before the Fellows at their annual meeting and must receive the affirmative vote of at least 90% of those present and voting.

Article II. Section (5)

Change to read as follows:

(5) Fellows shall compose a group of Active Members upon whom this title is conferred in recognition of outstanding contributions to Ceramic Arts and Science.

Eligibility for the grade of Fellow requires that Active Members shall be at least thirty years of age, shall have been enrolled as Active Members not less than five years and shall have won distinct recognition in the SOCIETY by (*a*) sustained interest in and devotion to the objects of the SOCIETY and high professional ideals, or (*b*) broad and productive scholarship in Ceramic Science, or (*c*) conspicuous achievement in some branch of the Ceramic Arts.

The methods to be used in judging the qualifications and determining the eligibility of nominees shall be devised and administered by the Fellows.

[1] November 7, 1932.

Article II. Section (6)

Change to read as follows:

(6) Nominations for promotion to the grade of Fellow must be made by seven or more Active Members of whom at least four must belong to the Division with which the nominee is affiliated, the application to be made by the sponsors upon a form approved by the Fellows and to comprise a full record of the nominee's educational, professional, and other qualifications.

All applications for promotion to the Fellowship must be transmitted by the Chairman of the nominee's division to the Chairman of Fellows who will in turn submit the proposal to the Fellowship Board which will act upon all such applications under the rules of the Fellows.

The Fellowship Board will consist of nine Fellows appointed by the Chairman of Fellows and will represent all Divisions of the SOCIETY. An affirmative vote of seven will be required for acceptance of the nominee for the grade of Fellow.

Notifications of acceptance will be transmitted by the Fellowship Board to the Chairman of Fellows who will forward such nominations to the Board of Trustees for ratification after which the nominee is duly elected and will be so notified by the Chairman of Fellows and publicly inducted into the Fellowship.

Induction of Fellows will take place at the next Annual Meeting of the SOCIETY following election to Fellowship unless circumstances necessitate some other arrangement.

Nominations not ratified by the Board of Trustees will be returned to the Chairman of Fellows and by him to the Fellowship Board, with the reasons for disapproval.

Nominations not accepted by the Fellowship Board will be laid on the table for one year, at the expiration of which time such applications may be taken up by the Fellowship Board for review and reconsideration or another application for the same nominee filed by the original or by another group of sponsors.

Persons elected to Fellowship shall be presented with a suitable certificate of election and may use the title Fellow, AMERICAN CERAMIC SOCIETY, or the abbreviation F.A.Cer.S.

Article II. Section (14)

In the fourth line change the reference to Article VII, Section 4 to Article VII, Section 3.

Article VII. Section (2)

Amend to read as follows:

(2) The Board of Trustees, Divisions, Committees, or any constitutionally organized group within the SOCIETY may refer to the Fellows any matters upon which the opinion of Fellows, as a group, is desired, such as matters of general policy and professional ethics.

Article VII. Section (3)

Delete.

Article VII. Section (4)

Amend to read as follows:

(3) In the event of the filing of written charges against any member of the SOCIETY, as provided in Article II, Section 14, the matter will be referred to a special committee of eight Fellows, one from each Division, appointed by the President of the SOCIETY. The Chairman of Fellows will serve ex-officio as chairman of this special committee.

The member against whom charges are directed shall be notified of such charges in detail and of the date for their consideration to provide full opportunity for appearance before the committee in person or by counsel or for the filing of a written defense.

The special committee of Fellows will report its findings and recommendations to the Board of Trustees which may accept or reject the recommendations, the decision of the Board to be final.

Article VII. Section (5)

Delete.

Article VII. Section (6)

Delete.

Article VII. Section (7)

Change the designation of this section from (7) to (4) and to read as follows:

"The affairs of the Fellows shall be managed by a Chairman, Vice-Chairman, and Secretary-Treasurer and such other officers as may be deemed necessary."

Ninety days prior to the Annual Meeting, the Chairman shall appoint two Nominating Committees, each to be composed of five members. Each Committee shall select a candidate for Chairman, a candidate for Vice-Chairman, and a candidate for Secretary-Treasurer by majority vote and report the names so selected to the Secretary of Fellows not less than thirty days prior to the Annual Meeting.

The Secretary shall send out to all Fellows printed ballots, bearing the names of the nominees of the two Committees in alphabetical order at least twenty days prior to the Annual Meeting. The ballots when voted and returned to the Secretary of Fellows, shall be turned over at the Annual Meeting to a Committee of two Scrutineers, to be designated by the Chairman, which shall promptly determine and report the results of the election of the officers.

Article VII. Section (8)

Amend to read as follows:

(5) There shall be held one or more meetings of the Fellows at each Annual Meeting of the SOCIETY, at such time and place as may be agreed upon, and the Secretary of the SOCIETY shall make provision for such meetings and place them upon the printed program of the Annual Meeting of the SOCIETY.

The Fellows will provide such programs for the meetings as they deem appropriate or desirable.

The Fellows may hold such other meetings as they deem necessary or desirable.

Article VII. Section (9)

Change the designation of this section from (9) to (6).

Article VII. Section (10)

Change to read as follows:

(7) The Board of Trustees shall make provision for the necessary expenses of the Fellows from the general funds of the SOCIETY, not to exceed 20% of the Fellowship dues, as prescribed in Section (2) of Article III of the Constitution.

NEW MEMBERS RECEIVED IN OCTOBER

PERSONAL

S. M. Stoin, Crooksville, Ohio.

E. Heikel Vinther, Research Engineer, Porcelainfabriken Norden, Valby Langgade 95, Copenhagen, Denmark.

STUDENT

Ohio State University

Fred O. Barber	**Joseph W. Moss**	**Robert F. Rea**
W. Leas Housley	**Burton E. Peck**	

Membership Workers' Record

Personal: A. E. Baggs, 1; H. O. Busch-Jensen, 1. *Student:* Office, 5. Total, 7.

CERAMIC ENGINEERING SHORT COURSE AT OHIO STATE UNIVERSITY

January 16 to 20, 1933

The Ceramic Engineering Department of Ohio State University announces a Short Course for practical ceramic men. This course will be devoted to raw materials, their mining, refining, and testing; the compounding and preparation of bodies, glazes, and enamels; and the forming and drying of ceramic ware.

The subjects of firing and decoration, and the classification and testing of finished products will be reserved for the Short Course to be given two years later.

At the proposed course, the subjects indicated will be covered in both fundamental and practical way by lectures and demonstrations.

The course will cover structural clay ware, refractories, enameled metals, and white ware, provided at least ten men register for each of these divisions. The registration fee will be $1.00 for the course instead of $5.00, which has been charged in the past.

CLAY PRODUCTS SHORT COURSE AT IOWA STATE COLLEGE

January 18 to 20, 1933

Clay workers are cordially invited to attend the Iowa Clay Workers' Short Course which will be held January 18, 19, and 20, 1933 at Iowa State College. There are no charges for this course.

Three subjects of vital interest to the structural clay products manufacturer, namely, drying, firing, and improvement of these products will be discussed by Walter Hull. Open discussion of these papers by Mr. Hull will be offered after each as delivered. Mr. Hull who was formerly with the Bureau of Standards has had a wide and varied experience in the field of structural clay products.

There will be a demonstration of a de-airing unit on a stiff-mud machine each afternoon, using samples of clay from the various plants, some samples of very plastic clays, others of very short clays. This is one of the most important improvements in the stiff-mud machine and this unit is being furnished by The Bonnot Co., of Canton, Ohio.

Additional features of the program are:

(1) "The Change of Fuel from Oil to Natural Gas on a Continuous Kiln," by Mark A. Taylor, Vincent Clay Products Co., Ft. Dodge, Ia.

(2) "Latest Reports on the Compression Test, and the Freezing and Thawing Test of Mortar Mix," by M. G. Spangler, Eng. Expt. Sta., Iowa State College.

(3) "Problems in the Use of Clay Products for Farm Buildings," by Henry Geise, Vice-President, American Society of Agricultural Engineers and Chairman of the Structural Division.

(4) "Terra Cotta Made on an Extrusion Machine," by D. J. Watson, Sioux City, Ia.

(5) "Description of Modern Switch Board for Recording Power Consumption," by R. B. Myers, Electric Eng. and Constr. Co., Des Moines, Ia.

(6) "Comparative Data on the Operation of Periodic, Continuous, and the Railroad Kiln (on same plant)," by Thos. H. Robertson, Chicago Heights, Ill.

(7) "Shrinkage and Drying of Clays," by Members of the Ceramic Engineering Staff.

BUY AMERICAN CERAMICS

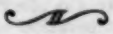
This is our slogan because

1st American Ceramic ware has no superior

2nd It gives work to American citizens

3rd It is necessary if our schools are to be financed

4th Return to economic normalcy requires that Americans hold every legitimate advantage for themselves



BUY AMERICAN CERAMICS

This slogan is to be emphasized the week of February 12 in Pittsburgh during the Thirty-Fifth Annual Meeting of the AMERICAN CERAMIC SOCIETY.

In preparation, a meeting of the china and glass ware manufacturers in the vicinity of Pittsburgh was called on Saturday, November 26, at the William Penn Hotel, Pittsburgh, Pa.

The Pittsburgh stores are cooperating. Special radio programs are being scheduled. Group and club meetings are being arranged. National publicity is provided.

BUY AMERICAN CERAMICS

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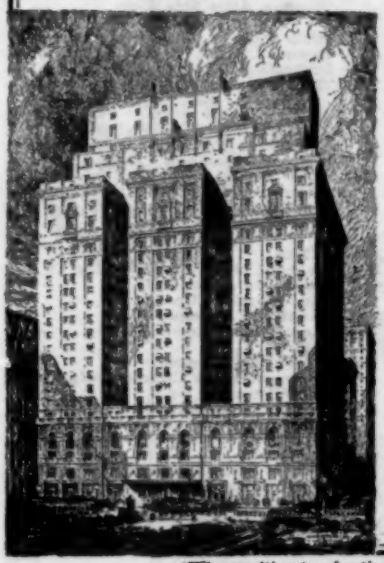

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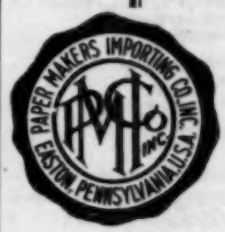

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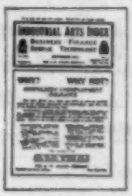

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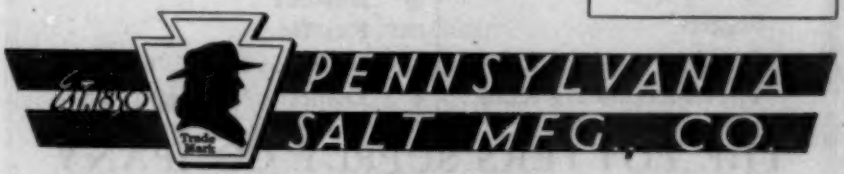

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